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ABSTRACT

This document presents witness testimony and supplemental materials from a Congressional hearing addressing the potential as well as the affordability of educational technology and the classroom of the future, where computers and computer networks will increasingly aid teachers and facilitate learning. Those presenting prepared statements are Congressman George E. Brown, Jr., Congressman William Clay, Congressman Robert S. Walker, Congresswoman Lynn C. Woolsey, Congresswoman Constance A. Morella, and Congressman Randy 'Duke" Cunningham. Testimony is included from: (1) Seymour Papert, Massachusetts Institute of Technology; (2) Alan C. Kay, Apple Computer: (3) Chris Dede, George Mason University; (4) David E. Shaw, D. E. Shaw & Company; (5) Ed McCracken, Silicon Graphics; (6) Pat Wright, TCI Educational Technologies, Inc.; (7) Robert W. Mendenhall, K-12 Industry Division, IBM; (8) Jeff Joseph, U.S. Chamber of Commerce; (9) Deborah McGriff, Edison Project; (10) Cheryl L. Lemke, Illinois State Board of Education; and (11) Alan S. Brown, Waukegan (Illinois) Public Schools District. Appendices include: statements for the record by Albert Shanker of the American Federation of Teachers, by Shelly Weinstein of the National Education Telecommunications Organization and EDSAT Institute, and by Geoffrey Teeter of Genentech, Inc., a report from the Office of Technology Assessment entitled "Teachers & Technology--Making the Connection," and various other supplemental materials including submitted pieces of correspondence and written testimony, a summary of educational technology expenditures by the Department of Education, press releases, a list of challenge grant recipients, Presidential remarks, and news clippings. (BEW)

IR

ED 392 400

EDUCATIONAL TECHNOLOGY IN THE 21ST CENTURY

JOINT HEARING

BEFORE THE

COMMITTEE ON SCIENCE

AND THE

COMMITTEE ON ECONOMIC AND EDUCATIONAL OPPORTUNITIES U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED FOURTH CONGRESS

FIRST SESSION

OCTOBER 12, 1995

[No. 23]

(Committee on Science)

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JOINT HEARING ON EDUCATIONAL TECHNOLOGY IN THE 21ST CENTURY

THURSDAY, OCTOBER 12, 1995

House of Representatives, Committee on Science, and Committee on Economic and Educational Opportunities
Washington, DC.

The committees met at 9 a.m. in Room 2318 of the Rayburn House Office Building, the Honorable Robert S. Walker, Chairman of the Committee on Science, and William F. Goodling, Chairman of the Committee on Economic and Educational Opportunities, presiding jointly.

Chairman WALKER. Good morning.

I'd like to welcome everyone to a hearing on educational technology. I think it's going to be a very exciting hearing. I was excited yesterday to have an opportunity to see the classroom of the future, and now to talk about some of the issues I think will make for a very worthwhile day.

And I'm very pleased that Chairman Bill Goodling and the members of his Committee, the Empowerment in Education Committee, have really cooperated with us in putting this together, and I'm pleased to welcome Chairman Goodling here today to be a part of this session.

Also, the ranking member, Bill Clay, when he arrives and of course—I'm sorry? There he is. All right. Bill, welcome. And of course the ranking member of the Science Committee, George Brown.

This is, as I say, I think an exciting glimpse into the future, and I'm delighted that we have the kind of cooperation.

What we're going to try to do throughout the day is alternate in and out of the chair, so there is a shared jurisdiction over this hearing.

We want to make certain that people understand that we're examining not just technology issues. This is really about education and how education deals with the future.

Speaker Gingrich had hoped at some point that he was going to be able to come and testify. He's not going to be able to do that with the press of other things. He is going to try to get over, at some point today, to the classroom of the future in 2325.

And any of you who have not had an opportunity to get there, we would certainly encourage you to go down and take a look at that display. It's very fascinating.

What I'd like to do is begin by asking the Committee Chairman and the ranking members who are here for their opening state-

ments, and so for the first statement, I will turn to Chairman Goodling.

Chairman GOODLING. The reason Mr. Clay was delayed over there coming in is in our Committee, we usually have a drum roll when he comes in, and he was waiting for that drum roll.

[Laughter.]

Chairman GOODLING. I have an opening statement that I'll submit for the record because I know we have a lot of people to testify.

I'd just indicate that I'm very interested in the subject and very interested in hearing the testimony. And then hopefully at the end, you will all also give us some ideas of how you put the dysfunctional family back together again so that my wife doesn't have to appear in a first grade class with 18 students, 12 of which are from dysfunctional families, and try to figure out what it is she's going to do to make sure they all receive an excellent education.

So I will submit my remarks for the record.

PREPARED STATEMENT OF CHAIRMAN WILLIAM F. GOODLING

Good morning, I would like to thank all of our distinguished panelists for appearing before the joint committee hearing on education in the 21st century. I am looking forward to listening to your thoughts on what you think our education system will look like 20 years into the future.

We have already seen so many rapid advances in the past few years, and they have changed almost every aspect of our daily lives. How we implement these new technologies in the classroom, how we train our teachers to teach with these new tools, and how effective these new resources are to student achievement are all issues that have emerged at the forefront of the discussions on education technology.

In my own congressional district both rural and urban education institutions have benefited from new developing technologies. Connecting schools and libraries has resulted in better student access to research and reading materials that otherwise would not be available to them.

Across the Nation, individual families and institutions of learning have begun to make investments in advanced technology. Yet little has been done to adequately instruct teachers on how to use technology as a teaching tool and to provide them with ongoing technical support.

More thought must be given on how to incorporate these new technologies with traditional subject matter and curricula because understanding the most basic concepts of subjects such as math and science are essential in both the workplace and in daily life.

I am pleased that we have a panel representing private industry here today. The need for partnerships between business and education is a fundamental one, and the involvement of business leaders in developing solutions that increase student performance is vital. The private sector is on the cutting edge of developing new technologies and they need to ensure that students learn the skills to compete in the business world.

Competitiveness in the future will rely on the education we give our children today. It is through efforts such as yours, reflecting foresight of our educational needs, that we will be able to avoid rude awakenings in our economic future.

I congratulate all of you on your leadership role in education policy and look forward to your testimony.

Chairman WALKER. Very good, I thank Mr. Goodling.

Mr. Brown, opening statement?

Mr. BROWN. Mr. Chairman, recognizing the scope of what we're doing and not desiring to take up too much money, too much time, let me——

[Laughter.]

Mr. BROWN. [continuing] money was on my mind, I'll tell you.

[Laughter.]

Mr. BROWN. Let me welcome the distinguished witnesses that we have before us this morning.

Let me indicate, without amplifying on it, that as the Chairman knows, this Committee on Science has had a long involvement with the questions of educational technologies and a strong record of support for them.

And let me also ask unanimous consent to insert in the record, a letter from the President's Science Advisor, indicating their strong support for the programs for enhancing education which modern technology makes available to us.

[The prepared statement and attachments of Mr. Brown follow:]

STATEMENT FOR HEARING ON
EDUCATIONAL TECHNOLOGY IN THE 21ST CENTURY
BY
THE HONORABLE GEORGE E. BROWN, JR. (D-CA)
RANKING DEMOCRATIC MEMBER
COMMITTEE ON SCIENCE

October 12, 1995

The uses of information technology in education have been studied, demonstrated and implemented, to varying degrees, over many years, beginning with films and television and now encompassing computers, CD-ROMs and the Internet. The capability for accessing and manipulating information by means of networked computers opens up new educational strategies for teaching problem solving skills and abstract concepts and also facilitates tailoring of instruction more to the individual needs of students. Network access enriches the educational resources available in the classroom and provides teachers with the means to collaborate with colleagues, share instructional materials and information, and access training for their own professional development.

The potential value of educational technology is manifest. The main issue is not whether these powerful tools can improve teaching and learning, but rather it is how to spur the deployment of the technologies as broadly as possible and integrate them in the curriculum in the most effective ways.

The Federal Government has long had an important role in sponsoring research and demonstration activities to advance educational technology and in supporting teacher training. The Administration has taken a lead in proposing new programs and augmentations to existing programs that will increase student access to modern computers, effective educational software, and national networks and that will help provide the training and support teachers need to employ new educational technologies effectively.

Unfortunately the general onslaught on the federal budget orchestrated by the Majority in the House has not spared education. The programs at the Department of Education that are most closely focused on educational technology -- Challenge Grants for Technology in Education, Star Schools, Ready-to-Learn Television, and Technologies Applications in the Individuals with Disabilities Act -- are targeted for cuts of 72 percent relative to FY 1995 appropriations and by 81% relative to the Administration's request. In addition to these programs focused on educational technology, a significant fraction of the resources provided by the formula grant programs authorized by Titles I, II and VI of the Elementary and Secondary Education Act support schools' access to educational technologies and training for teachers. The House-passed education appropriations bill will cut these activities by over 20 percent relative to the Administration's request. A summary of the cuts to these programs is attached to this statement.

The scale of the effort needed to make progress toward the widespread and effective use of educational technology is beyond dispute. While 75 percent of schools have computers, with an overall average of one computer for nine students, half are too out-of-

date to operate much of the best educational and general purpose software or to support network integrated systems. Actual use of computers averages just two hours per student per week, and the computers are rarely used to teach academic subjects. Similarly for network connectivity, 35 percent of schools have access to the Internet, but only 3 percent of instructional rooms have a network connection. And, only 3 percent of schools having some network connection report that students use the capability to a large extent.

There are many barriers to greater use of modern information technology in the schools. Not unexpectedly, cost leads the way. The Office of Technology Assessment has estimated that to provide one computer per desk with Internet access could entail a one time cost of as much as $145 billion and require $11 billion per year for operating costs and teacher training and support. But even if this level of resources were immediately available, other problems remain. While much has been learned about application of technology in education, further experimentation is needed to understand what works best, and how to replicate the best practices on a large scale. And perhaps most daunting of all, most of the 2.8 million k-12 teachers in the nation, who will ultimately determine the success or failure of applications of educational technology, have had little or no training in the use of the technologies.

To unleash the full potential of the technology will require an unprecedented commitment in time and effort by teachers and administrators, and must involve collaboration among all levels of government and between government and the private sector. This hearing can make a useful contribution if it addresses what steps are needed to effect change in accelerating the use of educational technology and how federal programs and policies can contribute to achieving that goal.

I do not assert that technology is a silver bullet that will instantly transform our schools, but the promise demonstrated by many applications of information technology warrants greater -- not reduced -- efforts to overcome the evident barriers to widespread deployment of technology. The cuts orchestrated in the House to federal programs that contribute to educational technology development and its effective use constitute a short-sighted policy that ignores the beneficial returns to society from investments in the development of human capital. Such ill-considered budget cuts will only harm and delay efforts to improve K-12 education, putting further off the time when America's schoolchildren may obtain a truly world class education.

THE WHITE HOUSE

WASHINGTON

October 11, 1995

The Honorable George Brown, Jr.
Ranking Member
Committee on Science
U.S. House of Representatives
Washington, D.C. 20515

Dear Congressman Brown:

I would like to commend you and the Members of the Committee on Science and the Committee on Economic and Educational Opportunities for your attention to the role that educational technology can play in achieving our nation's educational goals. There is no more important investment America makes than the investment we make in our children, and I share your belief that information technology gives us important new tools to prepare our children for today's technologically sophisticated economy. Attached you will find an open letter to parents from President Clinton and Vice President Gore outlining this opportunity and its importance to our country.

Interactive computer systems can bring resources from around the world into our classroom and give children powerful and exciting tools for exploring and experimenting with new ideas. These technologies have the potential to help our children learn better and our teachers to teach more effectively. New communication systems can help teachers upgrade their own skills and link them to other teachers, communities, and parents.

Knowing of your commitment to the potential of educational technology, I would draw your attention to two programs that work and that are playing a vital role in helping communities find ways to use new educational technologies in their schools. Most of the creative work and the investment needed to take advantage of education technologies in our schools will be achieved by businesses and local communities. However, the Technology Learning Challenge (TLC) education grants in the Department of Education and the Information Infrastructure Assistance Program (TIIAP) in the Department of Commerce are small federal programs that are playing a key role in building local partnerships and leveraging private sector support to stimulate the development and deployment of educational technologies. For that reason, I am concerned that Congress is considering deep cuts for both of these programs.

The Technology Learning Challenge grants has led to the establishment of 19 regional consortia linking local school systems, telecommunication and other

businesses, universities, museums, and others in a new kind of partnership. Each grant rewards an innovative local proposal for integrating innovative learning technologies into local curriculum needs. A total of $9.5 million in federal grants leveraged more than $70 million in local support and private sector funding. Hundreds of partnerships were formed to apply for these grants, and we are looking forward to encouraging more local efforts in the year to come. Unfortunately, the House of Representatives has proposed cutting $35 million from our request for FY96 and the Senate $15 million.

Information Infrastructure Assistance Program grants are given to public institutions to accelerate use of new communications technology. $24.4 million in federal funds has stimulated $64.4 million in innovative uses of communication technologies. Local enthusiasm generated by the program, and the need for funding, is underlined by the fact that we've received 200 times more applications than we can fund. Yet the House of Representatives has proposed cutting $40 million from the request for FY96, and the Senate would eliminate all funding.

The President, Vice President and I met with key business leaders and educators yesterday to discuss the potential of new technologies and what can be done to accelerate their use in schools. Several of the same people will be testifying in your upcoming hearing. We were impressed both by the breadth of the consensus and the depth of the conviction expressed by all members of the group. We agreed that moving technology into America's classrooms is something that can be done and must be done and agreed to work together in helping achieve this goal.

For this national commitment to succeed, the federal government needs to hold up its end and be prepared to support small, but critical, programs such as the TLC and the TIIAP which serve as catalysts for local innovation. We also must continue to invest in research in related areas which clearly serves the nation's interest but which can not be supported by private or state research investment.

I am delighted that you join us in our enthusiasm for the potential of educational technology and hope that we can work together to make technologically advanced classrooms a reality for our children in the near future. I look forward to working with you in this critical area.

Sincerely,

John H. Gibbons
Assistant to the President
for
Science and Technology

attachments

SUMMARY OF EDUCATIONAL TECHNOLOGY FUNDING BY THE DEPARTMENT OF EDUCATION

The Department of Education (DEd) supports several programs which provide support for enabling k-12 schools to acquire educational technologies, to train teachers in the uses of the technologies, and to integrate the technologies into the curriculum. Some of the assistance comes from targeted programs but much of it is part of more general education support, which allows the use of funds for educational technologies. The proportion of funds from the non-targeted programs that are used for educational technologies is not tracked explicitly; however, DEd has provided some estimates which are used to prepare the table below that shows educational technology support under these programs.

I. Programs Focused on Technology

1. Title III, Part A of the Elementary and Secondary Education Act (ESEA) authorizes 3 relevant programs:

    - National Programs for Technology in Education. The DEd Secretary is authorized to award grants to advance educational technology.

    - Regional Technical Support and Professional Development. Funds regional entities to provide technical assistance and support professional development of teachers related to educational technology.

    - National Challenge Grants for Technology in Education. Authorizes demonstrations of high intensity uses of technology in education.

2. Title III, Part B of the ESEA authorizes the Star Schools Act, which supports distance learning projects linking students and teachers over long distances using telecommunications technologies, such as satellites and fiber optic networks.

3. Title III, Part C of the ESEA authorizes Ready-to-Learn Television, which supports the production of educational and instructional video programming for preschool and elementary school students.

4. Title III, Part D of the ESEA authorizes the Telecommunications Demonstration Project for Mathematics, which provides grants to nonprofit entities for national projects demonstrating the use of telecommunications to improve mathematics teaching.

5. The Individuals with Disabilities Education Act (IDEA) includes as Part G the Technologies Applications program, which supports studies of the educational uses of new technologies for disabled students, designing and adapting technologies for the disabled, and helping to develop and market these technologies.

The following table lists the FY 1995 and proposed FY 1996 funding levels for the preceding educational technology programs:

[$ millions]

Program	FY 95 Approp.	FY 95, Post Rescission	FY 96 Request	FY 96 Approp. (House)
ESEA Title III, Part A	40.0	22.5	83.0	25.0
ESEA Title III, Part B	30.0	25.0	30.0	0
ESEA Title III, Part C	7.0	7.0	7.0	0
ESEA Title III, Part D	2.2	1.1	2.2	0
IDEA Part G	10.9	10.9	10.4	0
TOTAL	90.1	66.5	132.6	25.0

As shown by the preceding table, of the 5 DEd targeted educational technology programs, 3 suffered rescissions in FY 1995, which produced a cumulative cut of 26%. Also, 4 of the 5 programs were not funded for FY 1996 under the House-passed appropriations bill for the DEd. **The House appropriations bill cuts total funding for the 5 programs by 72% relative to the initial FY 1995 appropriations level and by 81% relative to the FY 1996 request.**

II. Programs Providing Some Support for Technology

1. Title I of the ESEA, the Compensatory Education Program, provides grants to local educational agencies for services to educationally disadvantaged students to improve academic performance. For FY 1995 the DEd estimates that 6.7% of the program's funds will be used to support educational technology. The following table assumes this percentage in estimating technology funding under the program for FY 1996.

2. Title II of the ESEA, the Dwight D. Eisenhower Professional Development Program, supports activities to strengthen the skills and knowledge of the elementary and secondary teaching force in all of the core academic subjects. Part A of the program provides for a broad range of professional development projects, including training teachers in applying technology in instruction. Part B allocates funds to the States by formula for uses including preparing teachers to use technology, and States are required to develop plans on how technology will be used to strengthen teachers' professional development. For FY 1995 the DEd estimates that 16% of the program's funds will be used to improve teachers' capabilities to use technology. The following table assumes this percentage in estimating technology funding under the program for FY 1996.

3. Title VI of the ESEA, Innovative Education Program Strategies (formerly Chapter 2 block grants), provides formula grants to States to support education reform activities, which may include acquisition of computer hardware and software for instructional use. For FY 1995 the DEd estimates that 36% of the program's funds will be used to support educational technology. The following table assumes this percentage in estimating technology funding under the program for FY 1996.

The following table lists the FY 1995 and proposed FY 1996 funding levels for the preceding education programs, including estimates for support of educational technology:

Program	FY 95 Approp.	FY 95 Post Rescission	FY 96 Request	FY 96 Approp. (House)
			[$ millions]	
ESEA Title I	6698.4	6698.4	7000.0	5555.0
[Ed Tech][1]	[450.0]	[450.0]	[469.0]	[372.2]
ESEA Title II,				
Part A	21.4	21.4	35.0	0
Part B	320.3	251.3	352.7[2]	263.8[3]
[Ed Tech][1]	[54.5]	[43.6]	[62.0]	[42.2]
ESEA Title VI	347.2	347.2	382.3[2]	286.1[3]
[Ed Tech][1]	[125.0]	[125.0]	[137.6]	[103.0]
TOTAL	7387.3	7318.3	8152.3	6104.9
[Total Ed Tech]	[629.7]	[618.6]	[668.6]	[517.4]

The preceding table shows that the House-passed appropriations for FY 1996 for educational technology within the 3 non-targeted DEd programs declined by 18% and 16% relative to FY 1995 appropriations for pre-rescission and post-rescission levels, respectively, and declined by 23% relative to the FY 1996 request level.

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[1] Portion of the preceding program estimated to support educational technologies.

[2] The Administration request was $735 million for ESEA Title II, Part B and $0 for ESEA Title VI, with the expectation that activities associated with Title VI would be folded into the formula grant component of the Eisenhower Program (Title II, Part B). The amounts shown split the $735 million between the two programs in the same proportion as the original appropriations for FY 1995.

[3] The House appropriations bill provided $550 million for these two programs but did not specify the level for each. The amounts shown split the $550 million between the two programs in the same proportion as the original appropriations for FY 1995.

George E. Brown, Jr.

Testimony submitted by Representative George Brown before U.S. House of Representatives Joint Hearing of the House Science Committee and the Economic and Educational Opportunities Committee, October 12, 1995.

Mr. Chairman:

[redacted] I am submitting this testimony on behalf of the JASON Foundation for Education, a non-profit educational organization in which I am a member of the Board of Directors.

The mission of the JASON Foundation for Education is to excite and engage students in science and technology, and to motivate and provide professional development for their teachers through the use of advanced interactive telecommunications. The Foundation enjoys the support and expertise of a unique alliance of public, private and non-profit organizations who are committed to the improvement of science and technical education for all students. JASON expeditions, supported by extensive professional development for teachers, award-winning curricula and resources on the Internet, feature live, interactive broadcasts from distinctive sites on our planet through advanced technologies in robotics, fiber optics, television production, computer science, mechanical and electrical engineering, and satellite communications.

This high-tech learning adventure was founded in 1989 by Dr. Robert Ballard after receiving thousands of letters from students asking him about his discovery of the wreckage of the *R.M.S. Titanic*. Administered by the JASON Foundation for Education, the yearly expeditions are designed to excite and engage students in science and technology, and provide professional development for their teachers. Competitively selected Student and Teacher "Argonauts" join Dr. Ballard and the team of JASON Project scientists on each expedition. Through advanced telecommunication networks, millions more students are able to participate live from Primary Interactive Network Sites (PINS) throughout the United States, Bermuda, the United Kingdom and Mexico.

In past JASON Projects, viewers discovered hydrothermal vents in the floor of the Mediterranean Sea, explored warships from the War of 1812 at the bottom of Lake Ontario, followed Charles Darwin's steps in the Galapagos Islands, observed migrating whales and the phenomenon of chemosynthesis in the Sea of Cortez off Mexico's Baja peninsula, excavated ancient Maya cities and explored the rain forests and coral reefs of Belize, and visited the world's most active volcano, Hawaii's Mt. Kilauea.

Advanced interactive telecommunications called "telepresence" allow students at the primary sites to watch the expedition live, interact with scientists and control remote operated vehicles. Video, audio and data signals will originate from the live broadcast in Florida. Signals are then converted to compressed digital video and uplinked to a satellite. The broadcasts will then be downlinked to the primary sites. All this occurs in less than half a second.

continued

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But the the JASON Project is much more than the two-week expedition. It is an international forum for teachers, researchers, students and others, providing unique opportunities for discussion of issues relating to science, education and teacher training. The project develops updates, expedition reports, research findings, curricula and other resources for teachers and is supported by supplemental cable broadcast programming.

JASON Online Systems provide an electronic medium for the sharing of ideas and experience related to the JASON Project. Students and teachers can access news and discussion groups to communicate with peers around the world. JASON Online Systems are also a vital part of the data gathering and sharing exercises of the Adapting to a Changing Sea curriculum. The JASON Project Homepage provides information on current and past Projects and features hypertext links, graphics, and video and sound clips. The URL for the homepage is http://seawifs.gsfc nasa.gov/JASON.html.

The JASON Foundation for Education is supported by a unique alliance of public, private and non-profit organizations that are committed to improvement of science and technical education for all students. EDS Corporation, a founding sponsor, is the technology provider to the JASON Project. Other National Corporate Sponsors are Bechtel Foundation, the National Geographic Society, Sprint, SUN Microsystems and Eastman Kodak Company. The State of Florida Department of Education is a partner for JASON VII.

The next expedition, JASON Project VII: Adapting to a Changing Sea, will take place April 15 - 26, 1996, in Key Largo, Florida.

JASON Project Voyage VII: Adapting to a Changing Sea will explore several interconnected shallow water habitats in Southern Florida to learn about "natural" cycles. Natural cycles are what would occur if environments were not affected by human existence. But since the majority of the world's population do live in coastal regions, JASON scientists, teachers and students will investigate life at the edge of the sea to see how humans impact natural cycles, both positively and negatively. The JASON team will analyze organisms and environments in diverse areas of the Florida watershed — the Everglades, Florida Bay, Florida Keys, and relic reefs in the Strait of Florida.

Using various advanced technologies, such as the U.S. Navy's nuclear submarine, the NR-1, remotely operated vehicles, and the National Undersea Research Center/University of North Carolina, Wilmington underwater laboratory AQUARIUS, which allows scientists to live underwater for extended periods of time, the JASON team will learn how humans can use conservation and technology to coexist with nature by the sea.

Chairman WALKER. Mr. Clay?

Mr. CLAY. Thank you, Mr. Chairman.

I also want to welcome the distinguished panelists today and look forward to their testimony.

and I would like to also submit my statement for the record.

[The prepared statement of Mr. Clay follows:]

PREPARED STATEMENT OF HON. WILLIAM CLAY

Mr. Chairman, sometimes the conventional wisdom is correct! In fact, sometimes it is so undeniably true that our failure to respond and change becomes clear for the whole world to see. In this case, the conventional wisdom tells us that the time of *one* teacher, using information found between the *two* covers of a textbook in a classroom with *four* walls, is over. That is the reality, and for the sake of our children and our Nation we need to act with vision and resolve.

The information revolution is forcing us to re-examine what is essentially a 100-year-old instructional model. Students must now process and critically analyze vast amounts of knowledge. Fortunately, today we know *far more* about how children learn than we did even 5 years ago. The theories of multiple intelligence and how that kind of intelligence influences learning are well known. What we need to know is how to apply that knowledge—using *the appropriate learning tools*—in the dynamic world of the classroom.

Having said that, Mr. Chairman, we need to face up to our failure to help students, teachers and schools meet this challenge. Four different reports issued in this year alone tell us that schools face major barriers in their efforts to leave behind the "blackboard and chalk" age and to enter an age of high performance learning environments.

I suspect we will hear quite a lot this morning about schools being part of "virtual communities." But evidence points very clearly to the fact that most schools are still facing the most basic problems "connecting-up." GAO has reported that 60 percent of inner-city schools and nearly half of rural area schools have wiring that could not sustain advanced telecommunications. Only 1 in 8 teachers have in their classrooms what nearly everyone has in their homes—a telephone.

Just last month, the **Committee for Economic Development (CED),** a well-regarded organization of business and education leaders, warned that the potential benefits of information technology will *not* be realized without a *substantial* improvement in the ability of teachers to integrate technology into the curriculum. The **CED** also calls for the Federal Government to *continue* its critical role in encouraging districts to expand the use of educational technology and in the supporting development of educational software, particularly programs serving low-income students.

In the last Congress, we made considerable progress in providing leadership and venture capital to local communities to help them increase the use of instructional technology. Incredibly, the House-passed **Labor/HHS Appropriations bill** would eliminate four of the five major education technology programs administered at the Federal level. This is not the action of visionaries. Rather, it is the action of reactionaries, rejecting both the reality and the promise of the Information Age.

Finally, Mr. Chairman, I hope in the very near future we will have another hearing to take testimony from the administration, which was not invited to testify today, on its national long-range plan on technology and education. The Department expects to complete that plan next month.

I look forward to hearing from our witnesses today. I have nothing but praise for the industries that have created the breathtaking innovations that have made the United States the world leader in this arena. However, it is our collective responsibility to extend the promise of innovation to every classroom and each and every student in this country. This will not be easy and it cannot be done on the cheap. It has been estimated that President Clinton's goal of connecting every classroom to the Internet by the year 2000 would cost $30 billion, with $5 billion in additional annual operating costs.

The goal of bringing American classrooms into the 20th century and getting them ready to teach in the 21st will be daunting. But, ultimately, we will achieve that goal if we decide that it is a national priority—as was the completion of the transcontinental railroad and the creation of the land grant colleges and universities. We should show no less commitment to our Nation's children.

UNITED STATES
DEPARTMENT OF EDUCATION

NEWS

FOR EMBARGOED RELEASE: 9 a.m. EDT
October 10, 1995

Contact: Melinda Kitchell Malico
(202) 401-1008

NOTE: Secretary Riley will be available via conference call Tuesday at 11 a.m. and 2 p.m. EDT to talk with reporters about the grants. Call (800) 495-0245, SCHOOLS (724-6657)

PRESIDENT SAYS TECHNOLOGY CHALLENGE GRANTS WILL HELP BUILD 21ST CENTURY SCHOOLS

WASHINGTON, Oct. 10 -- President Clinton today announced the first installment on a five-year commitment to move the nation's schools into the Information Age.

Flanked by Vice President Gore, Education Secretary Richard Riley and corporate leaders, the President announced 19 Challenge Grants for Technology in Education. The awards, totaling $9.5 million, are going to community partnerships with matching commitments of more than $70 million in the first year and over $300 million during the five-year span of the projects.

"Everywhere we look, technology is changing the way we work and live," President Clinton said. "Now, more than ever, it is imperative that our nation's schools have the technology they need to prepare students for the 21st century.

"The recipients of these challenge grants and their partners are committed to developing creative responses to the Information Age requirements of all students, including those in inner cities and rural areas. These grants will support visionary educators, parents, business partners and community leaders who are working to retool their schools for the [illegible]

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The challenge grant partnerships -- local consortia comprised of school districts and 380 partners representing business, education, libraries, museums, the military, states and cities -- will help infuse powerful new technologies into schools, allowing students and teachers to join the information superhighway. The partners have made substantial commitments for equipment, software development, technical support, telecommunications services and other costs.

"Powerful new technologies and the information superhighway can create unparalleled possibilities for extending the time, place and resources for learning," Riley said. "By linking schools to homes, libraries, museums, community centers and the workplace, these partnerships will expand learning opportunities for all students. The challenge grant communities being announced today will make these connections a reality -- and open schools to the abundance of educational resources available around the world."

The 19 grant recipients have formed partnerships with more than 134 other school districts in 23 states in the first year of the grant cycle. The partnerships also include more than 120 businesses, 34 universities and colleges, 10 museums, five libraries, 10 state education departments, education offices in five national and a state park system, two regional education laboratories, an energy laboratory, a Naval base and an Army base, and state and local government offices.

"These communities are responding to an ambitious challenge," Riley said. "Classrooms should be modern information centers for learning, [illegible] takes place with blackboards and chalk. The implications for education and economic [illegible]

MORE

competitiveness are enormous. Employers need well-educated employees who can use information technologies to gain knowledge and improve productivity. These grants will help schools and corporate partners make technology a part of effective teaching and learning."

First-year support for the projects comes from both fiscal year 1995 and 1996 funds; the grants announced today are funded with FY 95 funds. The Clinton administration is seeking Congressional support to fully fund the five-year grants at more than $85 million. Clinton requested $70 million for FY 96, but the House has recommended just $25 million and the Senate is considering funding of $15 million.

"At a time when hundreds of communities across the country are expressing their desire to meet the challenge of bringing their schools into the information age, it is tragic that Congress is considering cuts in this program, which would provide the resources they need for an effective response," Riley said. "Each federal dollar committed to this program is generating over $3 of additional local community investment in the future of our children. This is an investment in education and our future economic competitiveness that should not be lost."

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NOTE TO EDITORS: Attached is a list of grantees

FY 1995 CHALLENGE GRANTS FOR TECHNOLOGY IN EDUCATION

	CALIFORNIA	
Redwood City	San Mateo County Office of Education Contact: Joe Becerra (415) 802-5444	$550,000
San Diego	San Diego Unified School District Contact: Richard Fabian (619) 225-3416	510,241
	DELAWARE	
Dover	Capital School District Contact: William McGlumphy (302) 672-1521	550,000
	ILLINOIS	
Waukegan	Waukegan Community Unit School District 60 Contact: Elaine Armani (708) 360-5440	500,000
	INDIANA	
Anderson	Anderson Community School Corporation Contact: Terri Austin (317) 641-2151	300,000
Indianapolis	Indianapolis Public Schools Contact: John Kern (317) 226-4122	500,000
	LOUISIANA	
Natchitoches	Natchitoches Parish School Board Contact: Kerry Davidson (504) 342-4253	500,000
	MARYLAND	
Baltimore	Baltimore City Public Schools Contact: Michael Pitroff (410) 396-7607	624,712
	MICHIGAN	
White Cloud	Newaygo County Intermediate School District Contact: Larry Ivens (616) 924 0380	580,000
	NEBRASKA	
Omaha	Westside Community Schools Contact: Susan Manuel (402) 390 [illegible]	412,500
	NEW HAMPSHIRE	
Manchester	Manchester School District Contact: Terry B[illegible] [illegible] 624 [illegible]	500,000

	NEW MEXICO	
Laguna	Pueblo of Laguna Department of Education Contact: Gilbert Sanchez (505) 552-6008	$557,779
	OHIO	
Cuyahoga Falls	Summit County Office of Education Contacts: Steve Snyder / Gaye Fawcett (216) 945-5600	585,000
	PENNSYLVANIA	
Philadelphia	School District of Philadelphia Contact: Steven Guttentag (215) 299-4670	959,000
Towanda	Towanda Area School District Contact: Daniel Paul (717) 265-9894	462,107
	SOUTH DAKOTA	
Sturgis	Black Hills Special Services Cooperative Contact: Jim Parry (605) 394-1876	310,000
	TEXAS	
El Paso	Socorro Independent School District Contact: Ben DeBllis (915) 860-3438	342,500
	UTAH	
Price	Southeast Education Service Center Contact: F. Lynn Bills (801) 637-1173	333,999
	VERMONT	
Montpelier	Montpelier School District Contact: David Gibson (802) 223-6366	329,661

THE WHITE HOUSE

Office of the Press Secretary

October 10, 1995

REMARKS BY THE PRESIDENT
IN ANNOUNCEMENT OF TECHNOLOGY LEARNING GRANTS

The Roosevelt Room
9:28 A.M. EDT

THE PRESIDENT: Thank you, Mr. Vice President, for your outstanding work on this issue. And thank you, Secretary Riley and Secretary Brown, for your work as well.

I want to say a few more things about the people behind me and those in front of me, but if I might, in the beginning, I think it would be appropriate for me to make a few comments about what has happened to the Amtrak train in Arizona.

We believe it was a case of sabotage. And I am profoundly outraged by it. I want to make it clear that we will do everything we can with the federal government to catch whoever is responsible. I am determined that we will make sure that in the United States we will have the tools, the means we need to keep the American people safe. We will get to the bottom of this. We will punish those who are responsible. We will not tolerate acts of cowardice like this in the United States, regardless of the motive.

And when I know more about it I'll be glad to comment more about it.

I have just finished a meeting, along with the Vice President and other members of our administration, with leaders who are here behind me, leaders of many of the American companies on the cutting edge of the Information Age. They are helping to lead our nation into the world of the 21st century as the strongest economic power in the world.

Two and a half weeks ago in California, I met with some other business leaders, and I called on the representatives of business, government, teachers, schools, parents, students, to become involved in a high-tech venture with a guaranteed return. I asked for a national public-private partnership to connect every classroom in America to the information superhighway by the year 2000.

This today, this meeting, is the next step. Today these business and education leaders have joined with me to launch a partnership that will ensure that every child in America is technologically literate for the dawn of the 21st century, and that every child in America has the resources, the means, by which to become technologically literate by the dawn of the 21st century.

The idea that every child deserves the opportunity to build a bright future has been at the heart of America's education system and America's entire value system. Education is the way we keep the promise of the American Dream to all of our children without regard to their circumstances.

Today, that means computers, knowing how to make the most of them, having teachers who can work with students to make the most of them, and having the right software to make the computers make sense.

Technological literacy must become the standard in our country. Preparing children for a lifetime of computer use is just as essential today as teaching them the basics of reading, writing and arithmetic.

This isn't just computers for computers' sake. We're going to work together to help our schools use technology to revolutionize American education so that all children will be able to learn better and teachers will be able to be more effective.

In the next few months, the leaders here behind me will be working with us to produce a plan based on the four pillars I outlined in California: modern computers in every classroom, accessible to every student from kindergarten through the 12th grade; connections from every classroom to the incredible educational resources flowing throughout the world; teachers in every classroom who are trained to make the most of new technology to educate every student. And I want to emphasize one of the most important aspects of the technological revolution is the opportunities being opened to children so many Americans had given up on and schools that too many Americans had given up on. And finally, a rich array of educational software and information resources.

Today, I'm announcing three steps forward that show we are turning these principles into reality First, we're awarding Technology Learning Challenge Grants to 19 communities. In each community there's a partnership of educators, businesses, libraries, museums and community groups that have come together to retool their schools for the 21st century They are matching these grants. They are committing hardware and software, hard work, and know-how. For example, in Dover, Delaware, Bell Atlantic, Lightspan Partnership and the State Education Department are linking homes and schools through family tv sets to improve reading and arithmetic in the early grades This is how these partnerships will work.

Let me say that it costs a very modest amount of money. This is one of the discussions we have to have in the weeks ahead as we continue our progress toward a balanced budget We can balance the budget without cutting back on our commitment to our educational future For a very small amount of national money we are leveraging much larger amounts of local resources

And I would say again: this is the kind of thing that the nation ought to be doing now in the area of education and the sort of thing I will be trying to preserve as we negotiate the shelves of the budget discussions.

The second thing I want to announce is a private sector effort making a difference in one state is now going nationwide. We must rely on the expertise of millions of Americans working in the high-tech professions. The Technology Corps brings private sector volunteers into our schools so that they can bring technology into our classrooms. It's already working in Massachusetts where it was started by Gary Beach, who is here with us today, to connect Massachusetts schools. And now we want to do this around the country.

Finally, we're launching the American Technology Honor Society to harness the high-tech skills of exceptional students so they can help to expand their own school's use of technology. We have to remember that people born in the Information Age are more comfortable with it than people like me, who weren't. (Laughter.)

The American Technology Honor Society will be rooted in the National Honor Society, and it will be run by the National Association of Secondary School Principals. Communities, businesses and governments; parents, teachers and students -- this could be the largest merger in history, with no questions from the Justice Department. (Laughter.) Certainly it will be the most important partnership for the future in the United States today, working together to put a computer in every classroom, and a computer whiz at every desk.

Every child in America deserves the chance to get the high-tech know-how to unlock the promises of the 21st century. Every child in America. And thanks to the statesmanship and vision of the people who are here with me today and many like them all around America, we are going to forge a partnership to do just that.

Thank you very much. (Applause.)

END 9:35 A.M. EDT

Chairman WALKER. Thank you, Mr. Clay.

Chairman GOODLING. Mr. Clay didn't introduce our new member. Would you like to introduce our new member, Mr. Chairman?

Mr. CLAY. Is he here?

Chairman GOODLING. Yes, he's down on the end.

Mr. CLAY. Mr. Fattah is the new member of the Economic and, what is it, Education and Economics, Opportunity Committee, EEOC. For republicans, that's an oxymoron.

[Laughter.]

Mr. CLAY. But I'd like to introduce our new Committee member. This is his first meeting. Mr. Chaka Fattah from Pennsylvania. Welcome to the Committee.

Chairman GOODLING. Sometimes he doesn't put oxy in front of that when he addresses us.

Chairman WALKER. As two fellow Pennsylvanians, Chairman Goodling and I are happy to welcome you to the hearing today, and I'm sure to his Committee.

I too will ask unanimous consent to submit an opening statement for the record.

[The prepared statement of Chairman Walker follows:]

PREPARED STATEMENT OF HON. ROBERT S. WALKER, CHAIRMAN, COMMITTEE ON SCIENCE

The hearing will come to order.

Today we are going to explore a subject that is of vital importance to the future of our Nation. As a former teacher, I am painfully aware of the growing inadequacy of our traditional educational system. We may have the best system in the world at the collegiate level, but our K-12 system is simply not getting the job done. The problem has been analyzed in every imaginable way, but the simple statement that we will start the 21st century with essentially the same traditional educational system we had at the beginning of the 20th century, sums it up quite well.

Obviously, something has to give. We can't continue to rank 14th or 15th in the world in science education, and expect to sustain our economic competitiveness. Our world leadership, our national security and our standard of living are at stake here.

One force that will have a major impact on the future of education in the United States and the world is educational technology, and it is the purpose of this hearing to make our Members better acquainted with its tremendous potential. We can speak with some confidence about its potential because it is already flourishing elsewhere. Industry, forced to do its own training by the inadequacies of the schools, has developed educational technologies that are on the cutting edge of the art. Similarly, the military and other government agencies have created technology based training systems that are among the wonders of the world. Of course, these developments have been tailored to their applications, and whether they will translate into the traditional K-12 system is something to discuss with our witnesses today.

Industry is currently spending tens of billions of dollars per year on training, much of which should be done by the traditional schools. This motivates the industrial community to form partnerships with the schools to help them improve. In Europe and Japan, these partnerships are much more effective than in the United States. We hope our witnesses will tell us how we can catch up and even do better.

We have asked our witnesses to tell us what is going to happen to our K-12 system over the next 20 years. Will the K-12 structure survive? Will the teacher still be a "teacher?" What will be the instructional role of the computer? Will we see education approach its ideal of one-on-one Socratic learning? What will be the impact of the information superhighway on education, nationally and internationally? How important is affordable access to that highway and how do we pay for it? Will our educational bureaucracy stand in the way of the learning revolution?

These are just some of the issues for today's hearing. I am looking forward to a lively session that will leave us with a much greater understanding of the massive changes likely to take place in K-12 over the next 20 years. That awareness will help us with future education legislation, which may well determine our destiny as a nation.

Chairman WALKER. And I'm looking forward here today to a very lively session that will give us a greater understanding of the massive changes likely to take place in the K through 12 curriculum over the next 20 years.

That awareness will help us with future education legislation, and may determine very much the destiny of the country.

With that, we would be pleased to welcome our first panel of witnesses.

Other members with opening statement, I would say we would ask you to submit them to the record so that we do have an opportunity to hear as many of our witnesses as possible.

And without objection, we will take all opening statements that members may have prepared for the record.

[The prepared statements of Ms. Woolsey, Mrs. Morella, and Mr. Cunningham follow:]

PREPARED STATEMENT OF HON. LYNN C. WOOLSEY

My thanks to all of you who made this joint hearing, and the events which have accompanied it, possible. Those of you who know me from the Education Committee know that I truly believe that education is the future of this country. I also believe that technology must be in the future of education.

I'm lucky. I come from an area—Marin and Sonoma Counties in California—that has some of the finest thinkers, innovators, and users of technology in the entire country. Just last week I held a meeting in my district with technology experts from the business and academic communities to discuss what a national vision for technology in education should include. Over 50 people came to contribute their ideas on how schools in America should be using technology in the year 2000, and what we should be doing to get there from here. Since I don't have enough time to share all of their ideas with you this morning, I ask for unanimous consent to enter this outline of their recommendations into the record of this hearing.

Their recommendations start with what schools should think about before they purchase equipment and materials. This can be best summarized by a quote from the president of the College of Marin, James Middleton, who said that when investing in technology, we must learn to think in terms of tomatoes, not furnaces. Schools must balance long-range planning versus short-range consumption. And the curruculum should always come first, then the equipment, with a central plan for its use.

However, everyone agreed that "teachers teach, boxes don't" so that even the most cutting edge equipment is useless if teachers don't use it. Teachers will use technology if they have on-site training and support, particularly by their peers, and if they can clearly see unique applications for technology to help them reach their classroom goals. And we shouldn't forget that some of our best "on-site" technology teachers are students.

Ultimately, our schools should be part of a technology infrastructure that links schools to each other and to their community. The people who came to my meeting envision a time when schools will look more like workplaces and workplaces will look more like schools. Public/private partnerships between schools and businesses can create learning communities that offer all of us the gift of life-long learning.

A perfect example of how public/private partnerships can use technology to help teachers and students is a program called *Access Excellence*. *Access Excellence* grew out of relationships between some employees at Genentech, a biotechnology company in south San Francisco, and local high school science teachers. Through volunteer activities and conversations, Genentech employees became aware of how isolated science teachers feel, both from their peers and from the "real" world of science.

So, Genentech created a computer network forum for high school biology teachers. Using this electronic forum, teachers can share teaching ideas and lesson plans with each other. They can also obtain regular reports on new developments in all areas of biology and participate in an interactive bulletin board with working scientists.

In addition, Genentech joins with the National Science Teachers Association to choose exemplar high school biology teachers from each State and bring them to San Francisco for an *Access Excellence* summit. At the summit, these teachers learn how to use the online network to serve as leaders for other biology teachers nationwide.

This is only one example of the great things being done in my area using technology to improve education for everyone. I hope that this hearing today will increase both the enthusiasm for educational technology and the commitment to find ways to make it available to every student in every community.

VISION 2000: TECHNOLOGY IN EDUCATION

Recommendations by
Educational Technology Experts
in the
6th Congressional District
of California

Submitted by Rep. Lynn C. Woolsey

I. **Equipment and Materials**
   A. Before purchasing, schools should
      * make a plan
        - there should be someone whose job it is to plan
      * the plan should focus on the curriculum
        - curriculum first, then equipment
      * plan should be from the bottom-up
        - should have teacher input
   B. Tomatoes vs. Furnaces
      * must help public understand that technology equipment is not long-term
        - must plan for deterioration
      * long-range planning vs. short-term consumption
   C. What to Have
      * computers with adequate power
      * phone lines
        -teachers need phone lines in classrooms
      * modems
      * local area networks
   D. How to Keep Equipment Working
      * must have <u>trained</u> people to keep equipment operational
        - can't expect teacher to keep it current
      * can centralize expertise
        - don't need experts in every school
      * School-to-work Training for students

II. **Training Educators**
   A. teachers teach, boxes don't
   B. training should be site-based
   C. teachers make good teachers
      * peer training
      * peer support
   D. let the staff being trained help to plan what they are trained to do
      * training should be based on learners' needs
   E. use students to train teachers
   F. computers can train, too
   G. teachers have to want to use technology
      * show unique applications of techrology

- don't use technology to just translate what the teacher was already doing with a book

H. reward teachers who use technology innovatively

G. give teachers access to the equipment they need to use technology effectively
  * computer in every classroom

III. **Infrastructure**

A. Link schools to the community
  * make it easy for businesses to help in schools
    - tax incentives for businesses

B. Encourage mentoring programs betweens schools and communities
  * schools can't compete with the salaries that technology experts can get in private business

C. Life-long Learning
  * public access to educational technology
    - could be in libraries as well as schools

E. Sell benefits of educational technology to the public
  * if you own a car, you have an interest in maintaining the highway
  * if public sees benefits, will help with cost through bond issues, etc.

IV. **Uses of Technology**

A. Should reform schools and workplaces
  * schools should look more like workplaces and workplaces more like schools
  * break down the walls of school

B. Should prepare students for high-tech jobs
  * school-to-work programs

C. Create new learning communities
  * everybody teaches, everybody learns
  * public/private partnerships
  * schools and businesses responsible for each other

D. Create jobs
  * new entrepreneureal advancements
    - technology can create entrepreneureal spirits in students
  * improved productivity

PREPARED STATEMENT OF HON. CONSTANCE A. MORELLA

I want to commend Chairman Walker and Chairman Goodling for holding this important hearing to examine the future of educational technology.

In a society rich with information, we can no longer rely on skills appropriate only for the industrial age. We must use the technology that we have to excite young minds, otherwise we are wasting talent.

However, America faces many challenges in education. Budgets are being squeezed and local school districts, from Maryland to Montana, are being asked to do more with less. Our urban areas are overcrowded, and our rural areas are difficult to reach. Every student deserves access to a quality education. However, poor inner city and small rural schools may not be able to afford the resources to provide their students with the same educational opportunities available to students in wealthier communities. Therefore, it is in the Nation's best interest to make access to the latest technologies *affordable* to our public schools, no matter where they are located. I am committed to working to include language in the Telecommunications bill, soon to be considered in conference, to ensure that schools and libraries will have access to the Internet at affordable rates.

Since 1987, I have been working toward options for establishing a satellite dedicated to education. It is my understanding that approximately 33 percent of the 16,000 U.S. public school districts use one or more satellite dishes, with the greatest growth taking place in the 1992-1993 school year. More than 90 U.S. colleges offer degree and non-degree graduate and undergraduate courses through distant education reaching approximately one half million students.

I have learned, however, that the education sector faces a crisis from the lack of availability of satellite capacity and steep price increases that may cut back the growth in the use of telecommunications in education. I have written to the National Aeronautics and Space Administration (NASA) in the hope of getting help to solve the crisis in satellite services for the delivery of educational information. NASA may be in a position to offer a solution by employing an unused portion of their Tracking and Data Relay Satellite (TDRSS-6) for distance education. I also have introduced legislation with Congressman George Brown to provide a loan guarantee for an education satellite. Senator Conrad Burns has introduced similar legislation.

I look forward to hearing from the distinguished experts on our panels today who will address the future of educational technology. Whatever our visions for the future, we must address some of the barriers of the present that might hinder our ability to overcome the challenges of the technological revolution in the education community.

PREPARED STATEMENT OF HON. RANDY "DUKE" CUNNINGHAM

Good morning. I thank Chairman Goodling and Chairman Walker for calling this important and necessary hearing on Educational Technology in the 21st Century.

The matter of expanding technology into the public schools has long been an interest of mine. As Chairman of the House Subcommittee on Early Childhood, Youth and Families, as a former teacher and coach, and as someone who is committed and involved in improving public education, I find the current situation tragic.

Telecommunications technology and computers are revolutionizing the way we communicate with one another, transforming our businesses, and boosting the competitiveness of our natinal economy. But in a Windows '95, Pentium-chip world, we are educating the average American child in a horse-and-buggy school. The future of our Nation, and the opportunities our children have to achieve the American dream, depend upon whether we succeed at bringing our classrooms from the agricultural age into the Information Age.

Here are a few facts.

Of all the computers in 80,000 American schools, half are completely obsolete. What is the most common computer in schools? The Apple IIc (2-C), a museum piece.

The GAO plainly reported last April that "America's schools are not designed or equipped for the 21st century."

Only 12 percent of the Nation's classrooms have even one telephone line. And just 1 in 50 are connected to the Internet.

When jobs today in every field, not just the sciences, demand understanding and skill with technology, our schools simply leave children unequipped to the task. We must do better.

Let me give you a picture of the situation in my own congressional district, where knowledge and understanding of technology is probably higher than in other parts of the country.

San Diego City Schools recently built a new high school in the growing community of Scripps Ranch. They built it with technology in mind from the beginning. Students apply mathematics and engineering skills to architectural design on computers. Then they build modular units. The school sells those units, and reinvests the proceeds into more high-tech equipment and instruction. Local employers hire these students during the summer for work on more high-tech projects. These young people, whether they are going to college or not, are graduating prepared for the 21st century.

By contrast, the district's older high school in nearby Mira Mesa doesn't have the high tech equipment. It doesn't have the advanced computer network capability. The teachers and administrators do their best. But without the advanced technology, their graduates enter college or work at a disadvantage.

To address this challenge in a small way, I hold an annual TechFair in my district. TechFair brings together dozens of San Diego's high tech employers and researchers, with hundreds of local high school students. Our employers bring interactive computer workstations and displays. And the young people learn what opportunities await after graduation. They learn what kind of education they need to succeed in a high-tech world. They get a piece of the American dream.

Meanwhile, the American Federal Government has had only the most limited impact in bringing technology to American schoolchildren.

Congress has established a handful of programs, such as Star Schools for interactive satellite distance learning. Congress approved Technology Challenge Grants. That's good for successful grant applicants like San Diego city schools. But for the over 75 percent of schools who put millions of dollars worth of staff time and effort into submitting grant applications, the Clinton Administration's Challenge Grant is bringing their students no technology whatsoever. We need a plan to bring technology to every school, not another system of grant application roulette.

There is also a new education technology office at the U.S. Department of Education.

Nor have most local school districts invested seriously into technology. The San Diego City Schools, with Scripps and Mira Mesa, are at the leading edge of educational technology, but even they are behind the curve. When schools raise money for capital projects through bond issues, only about 6 cents on each bond issue dollar funds computers and technology. I have some advice for our schools who are having trouble passing bond issues: Parents, families, and communities will get far more energized about investing in technology for their children, than they will for parking lots and storage sheds.

Most recently, the Clinton Administration has pursued a P.S.P.R. policy to bring technology into the public schools. P.S.P.R. stands for Political Speech and Press Release. On a campaign swing through California, President Clinton offered to connect every school to the Internet by the year 2000. When asked how, he didn't know. He just thought it was a good idea.

On that goal, I agree with the President. But political speeches and press releases won't bring technology to our children. We must pursue a policy that will.

Experts say that a broadband, interactive telecommunications connection to every one of America's 80,000 public schools would cost about $10.2 billion. This is far short of the whole cost of truly integrating technology into education. It does not include classroom computers, or local networks, or training for teachers, or software. But we must begin somewhere, where there is a clear Federal interest. I believe that the Federal budget could afford to provide a broadband interactive connection to every school, had previous Congresses not buried the American people in deficits and debt. Our payments for interest on the debt this year alone run 20 times as large as the cost of providing this high-tech connection for our schools. Our children's future is already mortgaged. We cannot bury them in more debt, even for this worthy purpose.

There may be opportunity on another front. This fall, a House-Senate conference committee is hammering-out telecommunications reform legislation. This historic measure, which I supported during its House consideration, is intended to unleash creativity and competition in the telecommunications market, so that services we cannot even imagine today would soon be made available to many American consumers at an affordable price. I agree that the telecommunications bill can bring in a new American century of job growth and opportunity in high technology and information services.

Let me pose this question, then, to the regional Bell operating companies, to the long-distance companies, to the cable TV companies, and to the satellite and tele-

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communications technology companies: If this competition will have you fighting one another tooth and nail to provide greater service at lower cost, when will our schools and libraries get a piece of the action?

When will our 80,000 schools, and our thousands of public libraries, have an interactive, broadband telecommunications connection?

When? The year 2000? 2010? 2050? Name a date. You can send it to my office, 227 Cannon Building in Washington, the sooner the better.

For about $2 billion a year, every school can be connected to the cutting edge in telecommunications technology by January 1, 2001. The Senate bill already has a provision that gives State commissions with jurisdiction over telecommunications, plus the Federal Communications Commission, power to hold the industry accountable to do the job. Perhaps schools and communities could demonstrate partnership and commitment to the task, through an understanding that no connection be made to a school that has not first invested in appropriate technology itself.

These are simply proposals for your consideration. But they come from a strongly held belief; that we cannot let another generation of American children be born, then enter and graduate from school, without them learning and understanding technology. It is vital to their shot at the American dream. And it is vital to America's future.

If the companies which benefit from the telecommunications legislation cannot name a date by which they will have our schools connected with interactive broadband capability, then perhaps Congress should name a date for them, the sooner the better, and determine a funding mechanism.

I believe we can dream big dreams about bringing our schools into the 21st Century. I am encouraged that the Speaker, and many of those testifying here today, are thinking boldly about this issue. The question is whether we have the persistence and the courage to outlast all of those who say it cannot be done, and just do it.

As for me, I say that this is America. And in America, we can do anything.

Chairman WALKER. Mr. Fattah, did you have a question?

Mr. FATTAH. I just wanted to thank the Chairman and the ranking member for their gracious welcome to the Committee, and the Chairman I know from my work with the FIA Agency back in Pennsylvania, and the ranking member, Mr. Clay. I'm looking forward to working on the Committee.

Thank you.

Chairman WALKER. And again, we welcome you here today.

With that, we'd like to invite our first witnesses, panel of witnesses to the table.

[Pause.]

Chairman WALKER. We thank you very much for being with us today. I have an order on my panel that seems to kind of move across the table from my right to my left, so I think what we'll do is begin with Professor Papert. We would welcome your testimony.

STATEMENT OF PROFESSOR SEYMOUR PAPERT, LEGO PROFESSOR OF LEARNING RESEARCH, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASSACHUSETTS

Professor PAPERT. I see in front of me "Where there's no vision, the people perish." There is no vision in the education establishment about where education is going.

I think that's the main burden I'd like to make and I'd like to illustrate it by a series of little parables, rather than quote, facts which in the short time.

The first parable is about people in the 19th century who were doing research on how to improve transportation. Somebody stumbled on the idea of a jet engine and had the great idea that if we attached the jet engine to the stage coach, it would assist the horses by adding to their power. In fact, the opposition to this idea

said, no, don't do that. Let's train the stage coaches better, let's study why the wheels squeak, let's make better grease. Well, they won because they did experiments and they got results, and the other guy, the jet engine caused the stage coach to disintegrate.

What we're doing with technology in education is exactly analogous. We're putting computers and other technology in a school system that was designed for a totally different epoch where everything about it, the curriculum, its content, the idea of segregating children by ages, all this is the consequence of a system of knowledge-technology called the blackboard or the slate or the pencil and paper that required the dissemination of knowledge through presentation bit by bit by a teacher, so it had to be divided into subjects and the children had to be organized into grades and what could be taught was severely restricted by the conditions under which people, under which knowledge was disseminated.

I think that the problem is not how to stick the educational jet engine onto the educational stage coach. The problem is to invent the educational jet engine which is something that will be radically different in all its structure from what we see in schools today.

I object strongly to what you saw being called a classroom of the future. It's a classroom of the very, very, very near future. I doubt if there'll be "classrooms" in the real future. There'll be something else.

Obviously, there'll be places where children learn but they won't resemble what we see today.

I'd like to use one other little parable, and that's about we have a strong opinion in this world that some people can do things like mathematics, and some people can't. And some people can learn languages and some people can't.

Just focus on mathematics. Why do we think some people don't have a head for mathematics? It's because they didn't learn mathematics in the mathematics classroom.

But when we go into the French classroom and see how few children learn French, we do not conclude that they do not have a head for French, because we know that those very same children, if they grew up in France, would speak French perfectly.

So this is a total non sequitur that runs right through the whole thinking about our education, people's abilities, and who can learn what at what age.

The problem for mathematics education is not to find a better way of teaching mathematics in the classroom. The problem is to find the analog of learning French by growing up in France. It's to create a math land, math land being to mathematics what France is to French, and this is the great contribution of the computer.

It's not an automated teacher, it's not a way of presenting the same old curriculum. It's a mathematics speaking being, a medium, an instrument that would give children and everybody the opportunity to learn subjects like mathematics that we have thought of as too hard, too formal, too abstract, to learn this in the same kind of natural way as children can learn to walk, to talk, to manipulate their parents, to do all the things that children learn to do, without any curriculum and without any of our quizzes or national standards. They just learn these things because they live in a learning environment.

And our job is to convert this new technology into the infrastructure for that environment.

But in order to do that, we have to understand that there's an entire education establishment there, and by that, I mean, the administrations of the schools and the professors and the schools of education and the government agencies, and this whole structure which has been built around supporting and understanding an outmoded system.

And I think one has got to understand that this education establishment has very deep vested interests, not only for their jobs, but more important in their vision. Their vision is how to improve and keep going the old system. The vision is not how to envision and invent and foster the growth of something radically different.

And I think that that is the vision that we have to have. It's very hard to know how to translate that vision into what to do on Monday in the classroom, and we have to face that dilemma, but I think we can.

And I think that the job, the leadership role that our government can give is to recognize that problem, to recognize that when we look into the not very distant future, ten or 20 years, the present system will be totally antiquated in everybody's eyes, and I think we've got to foster the growth of something new in order to make an orderly transition possible.

One last parable, which isn't really a parable. I'm very struck by the analogy between the current state of our school system and the situation of the Soviet Union maybe ten years ago, when, at the time that Gorbachev came into power, it had become apparent that the system is collapsing, that it can't operate.

But it was also, although this was apparent from the outside, to the people inside, they tried to fix it by jiggering the details, by making local fixes within its bureaucracy.

I think we are in exactly the same position in our choice of and our approach to trying to fix our education system which needs a far more radical examination of what it's about, what the problems are, why it is what it is.

And when we do that, I think we might find that one of the reasons is exactly the same as what was wrong in the Soviet Union where they had a command economy where a committee somewhere decided on how many nails would be produced everywhere in the country.

This cannot work in a modern world. But we in our education system are trying to run the closest thing to a command economy in the form of a command curriculum where somehow we think we can dictate, whether it's at a federal or state or local level doesn't matter, we think we can dictate a same curriculum for every child irrespective of who that child is.

I think this is impossible for exactly the same reason. It's going to collapse. We have to recognize that it's going to collapse and see, unless we make and foster very rapid change in the system, it will break down in the same sort of disorderly way that we are beginning to see in some cities now and we saw in the collapse of that Soviet command economy.

I think that's enough. Thank you very much.

[The prepared statement of Professor Papert follows:]

TECHNOLOGY IN SCHOOLS: LOCAL FIX OR GLOBAL TRANSFORMATION?

REMARKS BY SEYMOUR PAPERT FOR A HOUSE OF REPRESENTATIVES PANEL ON TECHNOLOGY AND EDUCATION ON OCTOBER 12, 1995.

Readers interested in more information or in discussing the ideas presented here should use the following electronic addresses:
e-mail: School@media.mit.edu
URL:http://el.www.media.mit.edu/groups/el/projects/school

1. RECOMMENDATIONS.

1.1. The understanding in the Education Establishment of the consequences for education of digital technology is deplorably limited. The policy of Federal agencies is a grab bag of uncoordinated initiatives that provide neither vision of, nor leadership for, deep changes that are inevitable in as short a time-frame as the immediately coming decade. Even some initiatives that are exemplary in their short-term effects convey a wrong message for what might happen a few years ahead.

1.2. The question at stake is no longer whether technology *can* change education or even whether this is desirable. The presence of technology in society is a major factor in changing the entire learning environment. School is lagging further and further behind the society it is intended to serve. Eventually it will transform itself deeply or breakdown and be replaced by new social structures.

1.3. The open question is not whether but how. Will the transformation of schooling take place in an orderly, constructive manner or will we see aggravated versions of the breakdown already happening in some cities? Will public schooling survive? Will the needs of the economy be well served?

1.4. The Federal government cannot control the process of educational change but could provide leadership and vision. My recommendations include:

-- Turning educational institutions that are under federal control into model sites for far-reaching change. A no-cost example would be freeing the Job Corps from bureaucratic micromanagement and making innovation a criterion in bidding for management of Job Corps Centers.

-- Setting the sights higher in the formulation of national goals. For example it is pitiful that a national leader could see wiring each school to the internet as a significant goal. This would be a good thing, but a *minimal* level for a significant national technology-in-schools goal should be more like "several networked computers in every classroom within three years and a computer for every student within six."

-- Having the courage to support the idea that *all assumptions* about the content of the curriculum, the modes of learning and the structure of School are open to re-examination and

radical replacement as we move into the digital era. Recent initiatives such as Globe, the new standards and the new methods of assessment should be seen as baby steps in the right direction.

-- Creating a challenge to the technology industry to produce radically innovative low cost (for example $200) high performance networked portable educationally oriented computational devices.

--Creating a challenge to the "ideas industry" to produce radically innovative new concepts of intellectually rich curriculum without constraints imposed only because they have always been there such as inclusion of traditional topics (eg fractions or formal grammar), segregation of learners by age (K, 1, 2 etc) or artificial traditional divisions such as "science vs math vs writing" or "vocational vs academic."

-- Creating supportive conditions for visionary teachers (of which there are many) to "blow the whistle" about the deficiencies of "School as have known it" and join in the launching of a national debate about the future of the learning environment.

2. RESISTANCE TO CHANGE IN EDUCATION

2.1 Some sectors of human activity such as medicine, transportation and communications were transformed beyond recognition during the twentieth century Compared with such megachange the practices of school have been virtually static.

There are in principle two diametrically opposed visions of the role of new technologies in education. In one vision the technology is a means to bolster and improve established practices. In the other, the new technology renders these practices obsolete by creating the opportunity for radically new practices.

It is impossible to think sensibly about change and resistance to change in education unless one recognizes that the Education Establishment will not easily depart from the first view. It is held there by its intellectual paradigms as much as by its bureaucratic self-interest. Its professional structure reflects a certain model of education. So does its political and its financial base.

2.2 Reasons for the relative lethargy of educational change include the following:

-- Technology capable of producing an infrastructure to support megachange in education developed only in the last quarter, and largely in the last decade, of the past century;

-- Educational policy is dominated by a hierarchy of bureacracies at federal, state and local levels;

-- Educational thinking is dominated by an intellectual establishment (in schools of education, research institutes, federal agencies and elsewhere) whose culture formed under conditions of a lethargic pace of change;

--Since almost everyone has spent many years in schools, the image of "School as we have known it" is deeply imprinted in our collective and individual consciousness;

--Neither the general public nor education policy makers have access to elaborated descriptions of alternatives. As a result small modifications of the existing system can be presented as "radical innovation."

--There is widespread confusion about the costs of technology and the costs of failure.

The last two points will be amplified by some arithmetic in the next section and some parables in the following one.

3. THE MATHEMATICS OF THE COST OF TECHNOLOGY

The cost of technology is vastly exaggerated in the minds of education policy makers. The following factors enter the process:

3.1 The cost is seen in absolute and not in relative terms:

Consider the following *extremely* conservative assumptions for a school system:

School budget: $6,000 per student per year

Cost of a computer: $1000

Life of Computer: 5 years

Consequences:

Cost per year of providing every student with a computer is $200 a 3% increase in budget.

Cost of enough computer power in school to allow access whenever needed would be about 1% increase in budget.

3.2 Costs are based on retail prices of machines structured by an industry's perceptions of other markets:

-- Even without significant redesign of computers the above costs could be cut to half by hard bargaining for very large scale use.

-- An innovative design could produce an educationally powerful machine for a quarter of the above prices.

Thus: *the cost of providing every stucent with high quality computation is much less than the annual increase in cost of education due to inflation.*

3.3 Costs are not compared with the cost of school success and failure.

The above figures show that if the use of technology permitted a 5% improvement in the outcome of education it would be vastly cost-effective. If one adds to this costs of social services, loss of productivity, incarceration and other consequences of educational failure the figures are even more compellingly in favor of cost-effectiveness of investment in educational technology.

4. PARABLES

The following parables are intended to consolidate what I mean by my assertion that the Education Establishment has fallen victim to a fundamental error which I recapitulate as follows:

The Education Establishment has misunderstood the historical role of digital technology in relation to the education of children.

A pervasive error consists of seeing the technology as a way to *improve* the practices of contemporary School. In fact the technology makes them obsolete.

For the foreseeable future one can assume that there will be places children come together in order to learn. But almost every particular aspect of how these places will be organized will be different: certainly the "curriculum" will be radically different; the segregation of children by age and the fragmentation of knowledge into separate "subjects" may no longer be considered desirable. ETC. All these features of School can be traced to the lack of powerful knowledge-handling technologies.

4.1 First Parable

Physicians of a bygone era greet new medical technologies such as anesthesia and asepsis as providing an opportunity to improve their procedures .... for example they see ways to achieve wonderful improvement in the use of leeches for blood-letting.

4.2 Second Parable:

Nineteenth century researchers seeking to improve transportation stumble on the idea of a jet engine and propose to use it to augment the power of horses pulling stage coaches. Researchers of a rival school ridicule the idea of using technology to solve the problem and suggest that the better way is to train the coachmen. They cite careful experiments to show that stage coaches are slowed down by friction in the axle bearings. They demonstrate that a statistically significant improvement in speed can be obtained simply by training the drivers to use more and better grease.

Of course the anti-technologists were probably right in the short term. But the revolution in transportation was not going to come from studying axles and grease or by training coachmen in better skills. It would come through the invention of the airplane.

Of course the parables don't prove anything about technology and education. But they do set the tone for what has to be proved: the need and the possibility of inventing the educational airplane.

Chairman WALKER. Thank you very much, Professor Papert.
Dr. Kay.

STATEMENT OF DR. ALAN C. KAY, APPLE FELLOW LEARNING CONCEPTS, APPLE COMPUTER, LOS ANGELES, CALIFORNIA

Dr. KAY. Thank you.

I'd like to submit two documents for the record.

One is a Scientific American article I wrote a few years ago, which I think covers a lot of the issues. And another one is a short piece I wrote for this hearing.

Chairman WALKER. Without objection, they'll be included in the record.

Dr. KAY. Thank you.

For my short time here, I'd first like to say that I got started working with children in technology because of a visit to Seymour Papert in 1968, 27 years ago or so now. And I was struck immediately by his understanding and vision of how education and this new computer technology is going to play itself out, and I think he was right then, and I think he's right now.

There are some real problems in making it work. If the issue were music, for instance, if America's parents were worried that their children wouldn't make it in life unless they became musicians by the time they left high school, we could imagine Congress or some state legislature coming up with the solution of let's put a piano in every classroom. And they would say, but unfortunately, we don't have enough money to train the existing teachers or hire musicians, so what we'll do is we'll just give the existing teachers two-week refresher courses in the summer on music, and that should solve our problem.

And we know that music, as we know it, is not really going to get into the classroom.

Now the children will really enjoy having a piano in the classroom. They'll evolve a kind of chopsticks culture and maybe a little bit beyond. But that's basically what we're getting right now.

So part of what Math Land is and part of what any kind of environment for doing rich learning in is one in which the adults are invested in it as well.

I think this is the biggest problem that we have to deal with, because obviously American technology can produce as many computers for as low a cost as we need. We can saturate the entire world with computers, but to set up a sense of what its special music is is going to be very, very difficult, and I think that is what we should be aiming our efforts at.

And I'd like to say one other thing which is a famous, a Rabbi famous for his wisdom in Europe was once asked why the Jews keep the sabbath holy, and he said because man is not a beast of burden. And what he meant by that was not just that you shouldn't work one day a week, but he meant that being human isn't primarily about working.

So the most important thing here is to try and differentiate between all of the vocational demands that are being placed more and more heavily on society year by year, by parents, by businesses, and what education actually means.

If we take the pragmatic step of simply trying to deal with vocational problems and simply trying to institute training via computers in our schools, we will lose the larger battle and we'll lose it fairly soon.

And it's in part because it is not nearly as difficult for people to learn how to do new jobs as it is for them to have the flexibility to have change be a part of their lives. One of the biggest problems is, in today's business, is not in the intelligence or ability of people to learn; it's in the sense of having a large enough world view to see there's more things in life than the job that they're doing right now.

So I think that is a very important part.

And the third thing I would like to mention is that even though television is so deeply embedded in our society, it now seems to be the environment that people are exposed to. I think it is one of the worst things in the quantity that it is viewed for helping children understand how large the world is.

People like to say that people find out more from television now than they ever did in the past. But the problem is is what they find out is trivial, simple, and has very little to do with the kinds of thinking they're going to have to do when they grow up.

So learning is very entertaining when you do it, but entertainment often isn't particularly good learning.

Maybe television should be the last technology that America produced that doesn't have a Surgeon General's warning on it. It's something to think about.

Now my recommendations are kind of flimsy. And the reason is is because, as Seymour points out, we have an enormous situated bureaucracy for running education in this country. And the biggest tragedy is within it are many teachers who are completely dedicated to helping their students' lives.

But within this larger machine, I see very little chance of change in the direction that America needs. I think that is something that Congress and all of the people of this country are going to have to wrestle with for the next quite a few years.

I think setting up goals such as America will be the first in the world in science and math, as President Bush did a few years ago, completely misses all of the points.

One of the points it misses is that this is simply not possible. It will take decades to make changes from what has happened.

And it also misses the point about what the goals should actually be. The goals should be much more like this famous Rabbi which is that schools should not be just for learning how to make a living, but learning how to live.

Thank you.

[The prepared statement and attachments of Dr. Kay follow:]

Powerful Ideas Need Love Too!

—written remarks to Joint Hearing of the Science Committee and the Economic and Educational and Opportunities Committee, Oct. 12, 1995

by Alan Kay
Fellow, Apple Computer Corp.

Let me start the conversation by showing a video made by the National Science Foundation at a recent Harvard commencement, in which they asked some of the graduating seniors and their professors a few simple questions about what causes the seasons and the phases of the moon. All were confident about their answers, but roughly 95% gave explanations that were not even close to what science has discovered. Their main theories were that the seasons are caused by the Earth being closer to the sun in summer, and that the phases of the moon are caused by the Earth's shadow. Some of the graduates had taken quite a bit of science in high school and at Harvard. NSF used this to open a discussion about why science isn't learned well even after years of schooling. And not learned well even by most of the successful students, with high SATs, at the best universities, with complete access to computers, networks, and information.

My reaction was a little different. I kept waiting for the "other questions" that NSF should have asked, but never did. I got my chance a few weeks later after giving a talk at UCLA. I asked some of the seniors, first year graduate students, and a few professors the same questions about the seasons and the phases of the moon and got very similar results: about 95% gave bogus explanations along the same lines as the Harvard students and professors. But now I got to ask the next questions. To those that didn't understand the seasons, I asked if they knew what season it was in South America and Australia when it is summer in North America. They all knew it was winter. To those that didn't understand the phases of the moon, I asked if they had ever seen the moon and the sun in the sky at the same time. They all had. Slowly, and only in a few, I watched them struggle to realize that having opposite seasons in the different hemispheres could not possibly be compatible with their "closer to the sun for summer" theory, and that the sun and the moon in the sky together could not possibly be compatible with their "Earth blocks the suns rays" theory of the phases.

To me NSF quite missed the point. They thought they were turning up a "science problem", but there are thousands of science "facts" and no scientist knows them all; we should be grateful that the Harvard and UCLA students didn't "know the answers". What actually turned up is a kind of "math problem", a thinking and learning problem that is far more serious.

Why more serious? Because the UCLA students and professors (and their Harvard counterparts) knew something that contradicted the very theories they were trying to articulate and not one of them could get to that contradictory knowledge to say, "Hey, wait a minute..."! In some form, they "knew" about the opposite seasons and that they had seen the sun and the moon in the sky at the same time, but they did not "know" in any *operational* sense of being able to pull it out of their memories when thinking about related topics. Their "knowings" were isolated instead of set up to be colliding steadily with new ideas as they were formed and considered.

What was going on with them—and what similarly goes on with children every day in school? To understand this, we have to find out how we humans are "naturally" set up to think and learn.

We can get a clue from tne Bible. King Solomon was held to be the wisest man who ever lived and it says why: he knew more than 3000 proverbs! And proverbs work as follows: if you come home from a trip and your family is glad to see you, then "Absence made their hearts grow fonder". But it you come home from a trip and they aren't particularly glad to see you then the

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reason is...what? That's right, "Out of sight, out of mind". Each proverb exists to give meaning to a particular situation, and each is recalled on a case to case basis. If the proverb you use today (or the play or movie you see today) contradicts the one from last week, it is of no moment because proverbs and stories are evaluated mainly on how good they are *right now*, not how they compare to the other proverbs and stories in the pool.

This way of thinking and giving meaning to one's life and society in terms of stories and narratives is universal over all cultures, and is in our basic "wiring" as human beings. It is part of what we call "common sense". And it is the way most of the college students that NSF and I talked to had "learned science"—as isolated cases, stories that would be retrieved to deal with a similar situation, not as a system of inter-related arguments about what we think we know and how well we think we know it. Story thinking won out. Claude Levi-Strauss and Seymour Papert have called this incremental isolated "natural" learning: *bricolage* —which means making something by "tinkering around". This is one of the reasons that engineering predates science by thousands of years; some constructions can be accomplished gradually by trial and error without needing any grand explanations of why things work.

Yet if we look back over the last 400 years to ponder what ideas have caused the greatest changes in human society and have ushered in our modern era of democracy, science, technology and health care, it should be a bit of a shock to realize that none of these is in story form! Newton's treatise on the laws of motion, the force of gravity, and the behavior of the planets is set up as a sequence of arguments that imitate Euclid's books on geometry. All scientific papers since then are likewise given as special kinds of arguments, not stories. Tom Paine's *Common Sense* is a forty page argument about why monarchies are not a good form of government and why a democracy is likely to be better. (This was not actually "common sense", but "uncommon sense" since historically, the movement to democracy is incredibly rare.) The *Federalist Papers* are arguments that support different parts of the design of the Constitution. And the Constitution itself is a set of principles for building a very complex dynamic structure that should last for centuries whose "parts" (that is, us!) come and go and are only somewhat inter cooperative. It is most definitely not a story!

Recent studies have shown that less than 5% of American adults (less than 7% in the UK) have learned to think fluently in these modern non story forms. A recent perusal of the top 150 selling books in the US (as of Sept. 15th, thanks to www.usatoday.com) shows that 80% are in story form, 15% are self help books, 1.5% could be construed to have some scientific content, and none were in the form of serious argumentative essays. (Occasionally there appears an extended essay such as Bloom's *The Closing of the American Mind*, but none in the top 150 in Sept.). And these are percentages for the smallish number of Americans that buy books at all—remember that a bestseller is around 100,000 books, and a "run-away bestseller" is usually no more than 1,000,000 books in a nation of some 250 millions! Television, of course, is all about stories, and finds any other form almost impossible to deal with. Note, for example, how PBS deals with "serious subjects"—they are still given as stories, and at their very best, they function as ads for books that actually hold the real content.

Now my point here is not to urge that stories be given up. I love to hear and read them, and I love to see them enacted in the theater. If we couldn't think "story" in the theater, all we would see are actors in front of cardboard scenary supported by various noises from instruments in the pit. To enjoy theater, we have to give ourselves over to the narrative, experience actors as ourselves, the symbolic scenary as a place and mood, and the noises from the pit as stirring music. It works wonderfully well and we can participate deeply in what it means to be human via this process.

But now consider going to a similar building, with similar people on a stage uttering similar glorious sentences, all supported by symbolic scenary and stirring music. Sound like theater? But

here I am referring to a political rally. What we are so willing to surrender in theater, we had better hold on to with both hands here! Since our whole meaning of life and relationships with others require us to invest symbols with meaning and to give up part of ourselves to ideas, we have to get pretty sophisticated to work both sides of the street: to be tender-minded when our souls can be lifted, and be tough-minded when someone is trying to take them away from us. I believe that the main goal of learning is to learn that discernment, to learn how to make symbols work for us.

But just being able to criticize the kind of story in which we are embedded is not nearly enough, given that so much of important modern content, both politically and scientifically, is rendered in forms other than stories. In order to be completely enfranchised in the 21st century, it will be very important for children to get fluent in the three central forms of thinking that are now in use: "stories", "logical arguments", and "systems dynamics". The question is "how?".

One of the reasons advanced for why it is so difficult to get most children to learn to think in these new ways is that "this kind of thinking is hard to learn". But it is quite hard to learn to ride a bike, harder still to shoot baskets, and one of the hardest things to learn how to do is to hit a baseball consistently. If one watches children trying to learn these skills, what one sees is that they fail most of the time, but keep on trying until they learn, usually over years. This is more like their attitude when learning to walk and talk than the defeatism so often found in schoolwork. In fact, what really seems to be the case is that children are willing to go to any lengths to learn very difficult things and endure almost an endless succession of "failures" in the process if they have a sense that the activity is an integral part of their culture.

Montesorri used this very successfully in her schools. And Montesorri's ideas about "self-driven learning" were used much later in the design of the overlapping window interface on the Macintosh. Suzuki has had similar success in music learning via setting up a musical culture in which the child is embedded. Television and cultural continuity is very good at providing an environment that includes athletics and certain kinds of music and dance, and shows what it means to be highly skilled at them. An impressively large number of scientists either had a scientist parent or one who was extremely interested in science—sometimes just extremely interested in "learning as a high calling". Difficulty is not the real issue here. Belonging to a culture and building a personal identity are. We could call this "rite of passage" motivation.

If we hark back to the less than 5% estimates for the percentage of the American population that has learned to think in these new ways and recall that television is not a good medium to show these new ways of thinking, this means that most children will have no embedded cultural experience in these ideas before coming to school. I don't know what percentage of elementary school teachers have learned to think in these new ways, but I would guess from personal experience that it is very similar to that of the population as a whole. This means that it will be very unlikely for most children to experience these new ways of thinking at home or at school or through television—especially as embedded into the general ways of doing and thinking which are so important to how children assign value to what they are going to try *really hard* to learn.

Now something that is very hard to do, and which is not seen by a child as an important "rite of passage", is simply not going to be focused on with the intensity, stick-to-it-ness and tolerance of failure that is required to get over the hurdles. One of the great problems with the way most schools are set up is that the children quickly sense that most of the stuff they are asked to do is not "real", especially as opposed to optional activities like sports and games, art and music. They *know* these are "real", and a school has to go to great lengths to make them artificial enough for the children to lose interest.

Let me give an analogy to how the "setting up an environment" strategy might be dealt with—it is drawn from a learning experience I had as a child.

Suppose it were music that the nation is concerned about. Our parents are worried that their children won't succeed in life unless they are musicians. Our musical test scores are the lowest in the world. After much hue and cry, Congress comes up with a technological solution: "By the year 2000 we will put a piano in every classroom! But there are no funds to hire musicians, so we will retrain the existing teachers for two weeks every summer. That should solve the problem!" But we know that nothing much will happen here, because as any musician will tell you, the music is not in the piano—if it were we would have to let it vote! What music there is, is inside each and every one of us.

Now some things will happen with a piano in every classroom. The children will love to play around with it, and a "chopsticks culture" is likely to develop. This is "piano by *bricolage* . Some will be encouraged by parents to take lessons, and a few rare children will decide to take matters into their own hands and find ways to learn the real thing without any official support. Other kinds of technologies, such as recordings, support the notion of "music appreciation". It seems to turn most away from listening, but a few exceptions may be drawn closer. The problem is that "music appreciation" is like the "appreciation" of "science" or "math" or "computers"; it isn't the same as actually learning music, science, math, or computing!

But 50 years ago, I had the experience of growing up in a community that desired "real music for all", and found a way to make it work. It was a little town in New England that only had 200 students in the high school, yet had a tradition of having a full band, orchestra and chorus. This required that almost every child become a fluent musician. The secret is that every child starts off as a musician in their heart and each has a voice to sing with. They taught us to sing all the intervals and sight-read single parts in first grade. In second grade we sang two parts. In third grade we sang four parts and started to chose instruments. Talent was not a factor, though of course it did show up. This was something everyone did, and everyone enjoyed. I did not find out that this was unusual until I moved away. An important sidelight is that there *was* a piano in every classroom and all the teachers could play a little, though I am sure that at least one of the teachers was not very musical. What seemed to make it work was that the community had an excellent musical specialist for the elementary grades who visited each classroom several times a week. I remember that one teacher didn't like my phrasing in a song and tried to change it, but the specialist did like it and encouraged me to see if I could phrase the rest of the song that way.

The central point to this story is not so much that most of the children became fluent musicians by the time they got to high school—they did and had done so for generations—but that as far as I can tell, almost all still love and make music as adults (including me).

We can find this "create an embedded environment and support classroom teachers with visiting experts" strategy in a number of schools today. The Open Charter School of Los Angeles has succeeded in setting up a "design culture" in their third grade classrooms that embeds the children in a year-long exciting and difficult adventure in the large-scale design of cities. The most successful elementary school science program I know of is in all of the Pasadena elementary schools and is organized along the same lines. It was developed by Jim Bowers and Jerry Pines, two Caltech scientists, and the key is not just an excellent set of curriculum ideas and approaches, but that the classroom teachers have to gain some real fluency, and there is important scaffolding and quality control by expert circuit riders from the district.

To say it again, children start off loving to learn, and most can learn anything the culture throws at them. But they are best at learning ideas that seem to be an integral part of the surrounding culture. Having a parent or teacher that encourages them to study math and science

is not even close to having one that *lives* math and science (or seems to). This is the strongest pedagogical strategy I have encountered over more than 25 years of working with children. Technologies—such as books, musical instruments, pen and paper, bats and balls—can help, but they are clearly not enough to get kids over the critical hurdles all by themselves. On the other hand, literacy, music, art, dance, and sports can all flourish with little or no supportive technologies at all—supportive adults are all that are needed. An interesting exception to the need for supportive adults is when something becomes a "must" in the children's culture—like video games. John Holt once said that it would be much easier to teach math if it were made illegal! There have been a few attempts to get children to learn powerful ideas by embedding them in their own cultural rites of passage—none have been successful so far—but I think this has some real possibilities for the future.

A good rule of thumb for curriculum design is to aim at being *idea based*, not media based. Every good teacher has found this out. Media can sometimes support the learning of ideas, but often the best solutions are found by thinking about how the ideas could be taught with no supporting media at all. Using what children know, can do, and *are* often works best. After some good approaches have been found, then there might be some helpful media ideas as well.

Now let me turn to the dazzling new technologies of computers and networks for a moment. Perhaps the saddest occasion for me is to be taken to a computerized classroom and be shown children joyfully using computers. They are happy, the teachers and administrators are happy, and their parents are happy. Yet, in most such classrooms, on closer examination I can see that the children are doing nothing interesting or growth inducing at all! This is technology as a kind of junk food—people love it but there is no nutrition to speak of. At its worst, it is a kind of "cargo cult" in which it is thought that the mere presence of computers will somehow bring learning back to the classroom. Here, any use of computers at all is a symbol of upward mobility in the 21st century. With this new kind of "piano", what is missing in most classrooms and homes is any real sense of whether *music* is happening or just "chopsticks".

I have found that there are many analogies to books and the history of the printing press that help when trying to understand the computer. Like books, the computer's ability to represent arbitrary symbols means that its scope is the full range of human endeavors that can be expressed in languages. This range extends from the most trivial—such as astrology, comic books, romance novels, pornography—to the most profound—such as political, artistic and scientific discussion. The computer also brings something very new to the party, and that is the ability to read and write its own symbols, and to do so with blazing speed. The result is that the computer can also represent dynamic situations, again with the same range: from "Saturday Morning cartoons", to games and sports, to movies and theater, to simulations of complex social and scientific theories.

The analogy to a library of books and communication systems is found in the dynamic networking of millions of computers together in the Internet. Newly added are that one can use this new kind of library from anywhere on earth, it is continuously updated, and users can correspond and even work together on projects without having to be in the same physical location.

To us, working on these ideas thirty years ago, it felt as though the next great "500 year invention" after the printing press was being born. And for a few percent—very like the few that used the book to learn, understand, and debate powerful ideas and usher in new ways of thinking about the world—computers and networks are starting to be that important. The computer really is the next great thing after the book. But also as with the book, most are being left behind.

Here is where the analogy to books vs. television is most sobering. In America, printing has failed as a carrier of important ideas for most Americans. Few get fluent enough in reading to follow and participate in the powerful ideas of our world. Many are functionally illiterate, and most who do some reading, read for entertainment at home and for information on the job (viz. the 95% of bestsellers as stories and self-help). Putting the Federalist Papers on the Internet will eventually provide free access to all, but to have this great collection of arguments be slightly more accessible in the 21st century than it is today in public libraries will make no change in how many decide to read its difficult but worthwhile prose. Once again we are face to face with something that "is hard to learn", but has lost its perceived value to Americans—they ask why should they make the effort to get fluent in reading and understanding such deep content?

Television has become America's mass medium, and it is a very poor container for powerful ideas. Television is the greatest "teaching machine" ever created. Unfortunately, what it is best at teaching are not the most important things that need to be learned. And it is so bad at teaching these most important ideas that it convinces most viewers that they don't even exist!

Now computers can be television-like, book-like, and "like themselves". Today's commercial trends in educational and home markets are to make them as television-like as possible. And the weight of the billions of dollars behind these efforts is likely to be overwhelming. It is sobering to realize that in 1600, 150 years after the invention of the printing press, the top two bestsellers in the British Isles were the Bible and astrology books! Scientific and political ways of thinking were just starting to be invented. The real revolutions take a very long time to appear, because as McLuhan noted, the initial content and values in a new medium is always taken from old media.

Now one thing that is possible with computers and networks, that could get around some of the onslaught of "infobabble", is the possibility of making media on the Internet that is "self teaching". Imagine a child or adult just poking around the Internet for fun and finding something—perhaps about rockets or gene splicing—that looks intriguing. If it were like an article in an encyclopedia, it would have to rely on expository writing (at a level chosen when the author wrote it) to convey the ideas. This will wind up being a miss for most netsurfers, especially given the general low level of reading fluency today. The computer version of this will be able to find out how old and how sophisticated is the surfer and instantly tailor a progression of learning experiences that will have a much higher chance of introducing each user to the "good stuff" that underlies most human knowledge. A very young child would be given different experiences than older ones—and some of the experiences would try to teach the child to read and reason better as a byproduct of their interest. This is a "Montesorri" approach to how some media might be organized on the Internet: one's own interests provide the motivation to journey through an environment that is full of learning opportunities disguised as toys.

This new kind of "dynamic media" is possible to make today, but very hard and expensive. Yet it is the kind of investment that a whole country should be able to understand and make. I still don't think it is a real substitute for growing up in a culture that loves learning and thinking. But in such a culture, such new media would allow everyone to go much deeper, in more directions, and experience more ways to think about the world than is possible with the best books today. Without such a culture, such media is likely to be absolutely necessary to stave off the fast approaching next Dark Ages.

Schools are very likely the last line of defense against the global trivialization of knowledge—yet it appears that they have not yet learned enough about the new technologies and media to make the important distinctions between formal but meaningless activities with computers and networks and the fluencies needed for real 21st century thinking. At their best,

schools are research center for finding out interesting things, and like great research centers, these findings are best done with colleagues. There will always be a reason to have such learning centers, but the biggest problem is that most schools today are not even close to being the kinds of learning centers needed for the 21st century. We all need to help.

Three important things that Congress could do are:

- help school districts fund "specialist teachers" to support classroom teachers, especially in the elementary grades.
- support research to invent "high-content" media—the computer equivalent of the essay—to be one of the bases of the literacy of the 21st century
- help education to compete successfully with television in interest, and far exceed television in content

Will Rogers once said that its not what you don't know that really hurts you, but what you think you know! The best ploy here—for computing, science, math, literature, the arts, and music—is for schools to be quite clear that they don't know—they are the blind people trying to figure out the elephant—and then try to find strategies that will help gradually reveal the elephant. This is what the top professionals in their fields do. We find Rudolph Serkin in tears at age 75 accepting the Beethoven medal, saying "I don't deserve this" and meaning it. We find Nobel physicist Richard Feynmann telling undergraduates in his physics course at Caltech just how much he *doesn't* understand about physics, especially in his specialty! We can't learn to see until we realize we are blind.

The reason is that understanding—like civilization, happiness, music, science and a host of other great endeavors—is not a state of being, but a manner of traveling. And the main goal of helping children learn is to find ways to show them that great road which has no final destination, and that manner of traveling in which the journey itself is the reward.

FURTHER READING

Kay, Alan C., "Computers, Networks, and Education" *Scientific American*, September, 1991

Shamos, Morris H., *The Myth of Scientific Literacy*, Rutgers University Press, 1995

Computers, Networks and Education

Globally networked, easy-to-use computers can enhance learning, but only within an educational environment that encourages students to question "facts" and seek challenges

by Alan C. Kay

The physicist Murray Gell-Mann has remarked that education in the 20th century is like being taken to the world's greatest restaurant and being fed the menu. He meant that representations of ideas have replaced the ideas themselves; students are taught superficially about great discoveries instead of being helped to learn deeply for themselves.

In the near future, all the representations that human beings have invented will be instantly accessible anywhere in the world on intimate, notebook-size computers. But will we be able to get from the menu to the food? Or will we no longer understand the difference between the two? Worse, will we lose even the ability to read the menu and be satisfied just to recognize that it is one?

There has always been confusion between carriers and contents. Pianists know that music is not in the piano. It begins inside human beings as special urges to communicate feelings. But many children are forced to "take piano" before their musical impulses develop; then they turn away from music for life. The piano at its best can only be an amplifier of existing feelings, bringing forth multiple notes in harmony and polyphony that the unaided voice cannot produce.

The computer is the greatest "piano" ever invented, for it is the master carrier of representations of every kind. Now there is a rush to have people, especially schoolchildren, "take computer." Computers can amplify yearnings in ways even more profound than can musical instruments. But if teachers do not nourish the romance of learning and expressing, any external mandate for a new "literacy" becomes as much a crushing burden as being forced to perform Beethoven's sonatas while having no sense of their beauty. Instant access to the world's information will probably have an effect opposite to what is hoped: students will become numb instead of enlightened.

In addition to the notion that the mere presence of computers will improve learning, several other misconceptions about learning often hinder modern education. Stronger ideas need to replace them before any teaching aid, be it a computer or pencil and paper, will be of most service. One misconception might be called the fluidic theory of education: students are empty vessels that must be given knowledge drop by drop from the full teacher-vessel. A related idea is that education is a bitter pill that can be made palatable only by sugarcoating—a view that misses the deep joy brought by learning itself.

Another mistaken view holds that humans, like other animals, have to make do only with nature's mental bricks, or innate ways of thinking, in the construction of our minds. Equally worrisome is the naive idea that reality is solely what the senses reveal. Finally, and perhaps most misguided, is the view that the mind is unitary, that it has a seamless "I"-ness.

Quite the contrary. Minds are far from unitary: they consist of a patchwork of different mentalities. Jerome S.

ALAN C. KAY has been a fellow of Apple Computer Inc. since 1984. Before joining Apple, he was a founder and fellow of the Xerox Palo Alto Research Center and, later, chief scientist of Atari. One of the pioneers of personal computing, he is the original designer of the overlapping-window user interface and Smalltalk, the first completely object-oriented language. Kay has worked with children for most of his career because, he says, "the media that powerfully shape our ways of thinking must be made accessible as early in life as possible." His interests outside of computing include musical performance and instrument design and "trying to learn more about the world in which we find ourselves." He also plays tennis whenever he can.

STUDENTS at the Open School: Center for Individualization, in Los Angeles, are creating a dynamic simulation of ocean life (*right*) and doing math (*above*) with the help of Macintosh computers, which are set unobtrusively into the desks. In the Open School, which already had a strong curriculum before it obtained computers, the machines do not substitute for teachers. They are thought of as "just another material," like books, paints and clay, that can support the children's activities. In the next few years, notebook-size computers are expected to become available; then children will be able to carry their computers anywhere they go.

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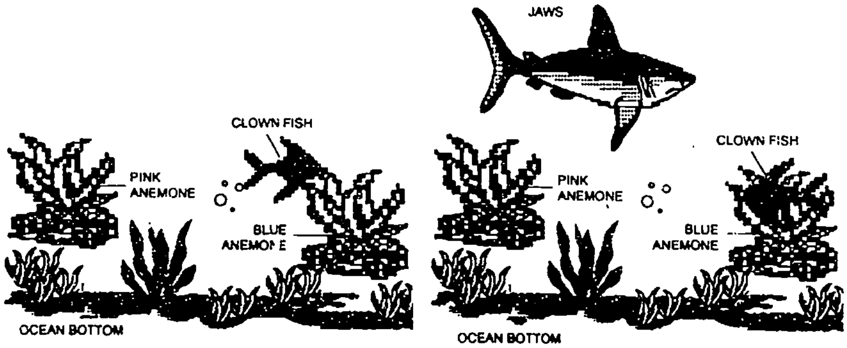


CLOWN FISH IS FEATURED in an ocean simulation constructed by nine- and 10-year-olds at the Open School. The fish repeatedly brushes up against an individual sea anemone (*left panel*) to build immunity to its poisonous stings. After immunity is established (*right panel*), the fish can take refuge among the anemone's tentacles whenever a predator (here a shark named Jaws) is near. By constructing simulations, the children learn more about the challenges of being a clown fish and the benefits of symbiosis than they would if they engaged only in more passive activities—such as reading books and observing a fish tank. The author argues that adults, too, learn best when they can test ideas through simulation.

Bruner of New York University has suggested that we have a number of ways to know and think about the world, including doing, seeing and manipulating symbols. What is more, each of us has to construct our own version of reality by main force, literally to make ourselves. And we are quite capable of devising new mental bricks, new ways of thinking, that can enormously expand the understandings we can attain. The bricks we develop become new technologies for thinking.

Many of the most valuable structures devised from our newer bricks may require considerable effort to acquire. Music, mathematics, science and human rights are just a few of the systems of thought that must be built up layer by layer and integrated. Although understanding or creating such constructions is difficult, the need for struggle should not be grounds for avoidance. Difficulty should be sought out, as a spur to delving more deeply into an interesting area. An educational system that tries to make everything easy and pleasurable will prevent much important learning from happening.

It is also important to realize that many systems of thought, particularly those in science, are quite at odds with common sense. As the writer Susan Sontag once said, "All understanding begins with our not accepting the world as it appears." Most science, in fact, is quite literally non-sense. This idea became strikingly obvious when such instruments as the telescope and microscope revealed that the universe consists of much that is outside the reach of our naive reality.

Humans are predisposed by biology to live in the barbarism of the deep past. Only by an effort of will and through use of our invented representations can we bring ourselves into the present and peek into the future. Our educational systems must find ways to help children meet that challenge.

In the past few decades the task before children—before all of us—has become harder. Change has accelerated so rapidly that what one generation learns in childhood no longer applies 20 years later in adulthood. In other words, each generation must be able to quickly learn new paradigms, or ways of viewing the world; the old ways do not remain usable for long. Even scientists have problems making such transitions. As Thomas S. Kuhn notes dryly in *The Structure of Scientific Revolutions*, a paradigm shift takes about 25 years to occur because the original defenders have to die off.

Much of the learning that will go on in the future will necessarily be concerned with complexity. On one hand, humans strive to make the complex more simple; categories in language and universal theories in science have emerged from such efforts. On the other hand, we also need to appreciate that many apparently simple situations are actually complex, and we have to be able to view situations in their larger contexts. For example, burning down parts of a rain forest might be the most obvious way to get arable land, but the environmental effects suggest that burning is not the best solution for humankind.

Up to now, the contexts that give meaning and limitation to our various knowledges have been all but invisible. To make contexts visible, make them objects of discourse and make them explicitly reshapable and inventable are strong aspirations very much in harmony with the pressing needs and onrushing changes of our own time. It is therefore the duty of a well-conceived environment for learning to be contentious and even disturbing, seek contrasts rather than absolutes, aim for quality over quantity and acknowledge the need for will and effort. I do not think it goes too far to say that these requirements are at odds with the prevailing values in American life today.

If the music is not in the "piano," to what use should media be put, in the classroom and elsewhere? Part of the answer depends on knowing the pitfalls of existing media.

It is not what is in front of us that counts in our books, televisions and computers but what gets into our heads and why we want to learn it. Yet as Marshall H. McLuhan, the philosopher of communications, has pointed out, the form is much of what does get into our heads; we become what we behold. The form of the carrier of information is not neutral; it both dictates

the kind of information conveyed and affects thinking processes.

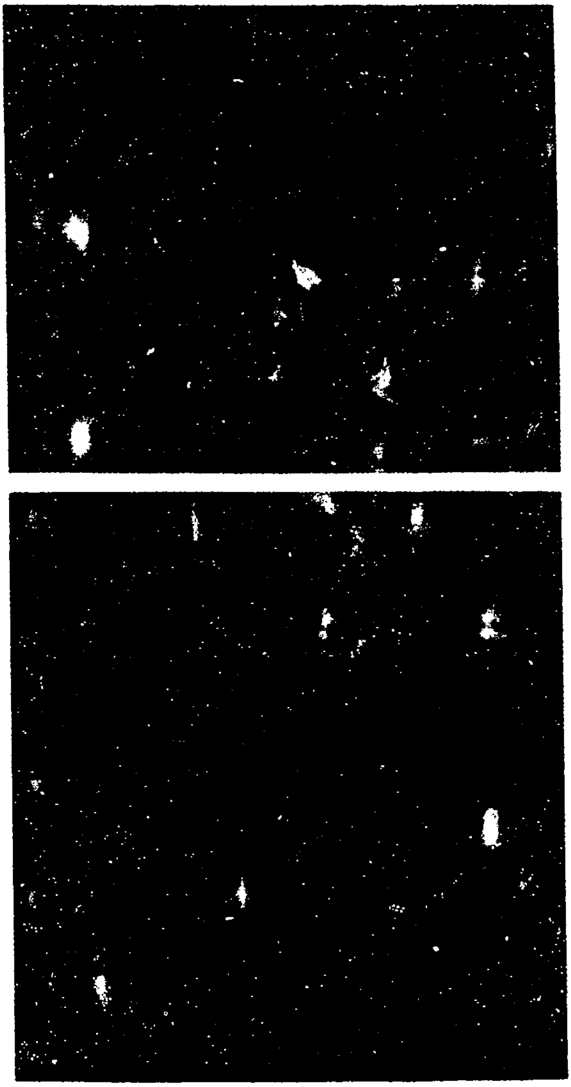
This property applies to all media, not just the new high-tech ones. Socrates complained about writing. He felt it forced one to follow an argument rather than participate in it, and he disliked both its alienation and its persistence. He was unsettled by the idea that a manuscript traveled without the author, with whom no argument was possible. Worse, the author could die and never be talked away from the position taken in the writing.

Users of media need to be aware, too, that technology often forces us to choose between quality and convenience. Compare the emotions evoked by great paintings and illuminated manuscripts with those evoked by excellent photographs of the originals. The feelings are quite different. For the majority of people who cannot make such comparisons directly, there is an understandable tendency to accept the substitution as though nothing were lost. Consequently, little protest has been made over replacing high-resolution photographs of great art (which themselves do not capture the real thing) with lower-resolution videodisc images (which distort both light and space even further). The result is that recognition, not reverie, is the main goal in life and also in school, where recognition is the highest act to which most students are asked to aspire.

When convenience is valued over quality in education, we are led directly to "junk" learning. This is quite analogous to other junk phenomena, pale substitutions masquerading for the real thing. Junk learning leads to junk living. As Neil M. Postman of New York University says, whether a medium carries junk is not important, since all media have junk possibilities. But one needs to be sure that media incapable of carrying important kinds of discourse for example, television do not displace those that can.

Media can also lure us into thinking we are creating by design when in fact we are just tinkering. Consider the difficulty of transforming clay a perfectly malleable and responsive substance into anything aesthetically satisfying. Perfect "debugability," or malleability, does not make up for lack of an internal image and shaping skills. Unfortunately, computers lend themselves to such "clay pushing"; they tempt users to try to debug constructions into existence by trial and error.

Finally, as McLuhan noted, the instant communication offered by today's media leads to fragmentation. Sequence and exposition are replaced by isolated,



WALKWAY through a garden (*top*) outside the Open School was designed by the third graders, who chose a herringbone pattern to ensure easy access to all plots. The children settled on the pattern after creating and debating many models, often with the help of their computers. The garden is part of the Life Lab project, in which children plan, plant, tend and enjoy the fruits of their own garden (*bottom*) as a way of learning about the interaction of living things with the environment.

context-free factoids, often presented simply because they are recent. Two hundred years ago the Federalist papers—essays by James Madison, Alexander Hamilton and John Jay arguing for ratification of the U.S. Constitution—were published in newspapers in the 13 colonies. Fifty years later the telegraph and its network shifted the goals of news from depth to currency, and the newspapers changed in response. Approximately 100 years after that, television started shifting the emphasis of news from cu' ..ncy to visual immediacy.

Computers have the same drawbacks as other media, and yet they also offer opportunities for counteracting the inherent deficits. Where would the authors of the Constitution publish the Federalist papers today? Not in a book; not enough people read books. Not in newspapers; each essay is too long. Not on the television; it cannot deal with thoughtful content. On computer networks? Well, computer displays, though getting better every year, are not good enough for reading extended prose; the tendency is to show pictures, diagrams and short "bumper sticker" sentences, because that is what displays do well.

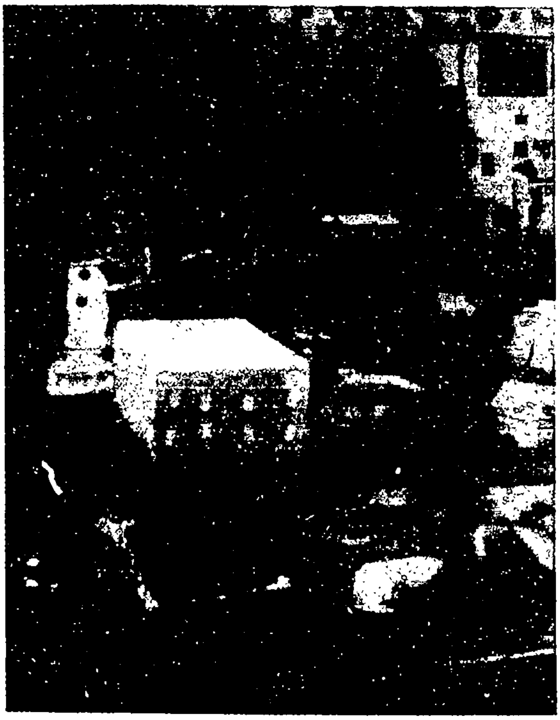
But the late 20th century provides an interesting answer to the question: transmitting over computer networks a simulation of the proposed structure and processes of the new Constitution. The receivers not only could run the model but also could change assumptions and even the model itself to test the ideas. The model could be hyperlinked to the sources of the design, such as the constitution of Virginia, so that "readers" might readily compare the new ideas against the old. (Hyperlinking extends any document to include related information from many diverse sources.) Now the receivers would have something stronger than static essays. And feedback about the proposals—again by network—could be timely and relevant.

Five years ago, intent on studying firsthand the strengths and weaknesses of computers as amplifiers for learning, my colleague Ann Marion and I, in collaboration with the Open School: Center for Individualization, in Los Angeles, set up a research project called the Apple Vivarium Program. We and the principal, Roberta Blatt, were not trying to improve the already excellent school by introducing technology. We were trying to better understand the value computers might have as supporting media.

Children are bused in and, as is the case with other busing schools in Los Angeles, are selected by lot so that the racial balance is roughly in accord with that of the city as a whole. Parents have to be interested enough in their children and the school's teaching approach to put their children on the list for consideration. Parental interest and involvement are key factors that have made the school a success. One could even argue that the educational approach in a classroom is not nearly as important as the set of values about learning found in the home. If those exist, almost any process will work, although some may be more enjoyable and enriching than others.

We particularly wanted to investigate how children can be helped to understand that animals, people and situations are parts of larger systems that influence one another. We therefore focused much of our work on the study of biology and ecology. Studies of the design and functioning of large cities also give children an awareness of such complexity. Doreen Nelson of the California Polytechnic Institute has been teaching city design to children for many years; on the basis of her work, our study group introduced a large-scale city-building project for the third graders. We also helped the school develop a major theater program, so the children might see how art and systems work from the inside.

What does it mean to learn about biology as it relates to us and our world? All creatures consist of and are part of many systems that range from the molecular to the planetary. A weak way to approach this romance - in which we are at once part of the scenery, bit



MODEL CITY was built by third graders at the Open School after months of planning. Although the children erected the buildings by hand, they turned to their computers for assistance on a number of jobs. For instance, the computers helped the students simulate the formation of smog in their city.

PLOT OF TEMPERATURES in the Great Lakes region of the U.S. is part of an international map created from data collected by students in hundreds of schools. The children took measurements at the same time of day and pooled them through a network. Making such maps is part of the *Weather in Action* unit of the National Geographic Kids Network curriculum. It is also an example of how networks can enhance scientific collaboration—for children as much as for adults.

players, star-crossed lovers, heroes and villains—would be a well meaning attempt to use books, computers or other representational media as "delivery vehicles." There could be videodiscs showing plant and animal growth, and the students could have network access to data about crop yields, taxonomies of animals and plants, and so forth. But why substitute a "music appreciation" approach for the excitement of direct play? Why teach "science and math appreciation," when the children can more happily (and to better effect) actually create whole worlds?

What is great in biology and humankind's other grand investigations cannot be "delivered." But it can be learned—by giving students direct contact with "the great chain of being," so that they can internally generate the structures needed to hold powerful ideas. Media of all kinds can now be used to amplify the learning experience, whereas before they acted as a barrier to the "good stuff."

The Open School is nothing if not straightforward. Because "things that grow" is the essence of what is called the Life Lab program, the children made a garden, tearing up part of their asphalt playground to get good clean dirt. The third graders, while in the midst of their city-building project, spent months modeling and debating designs for the garden. They ultimately arrived at a practical, child-scaled pattern featuring a herringbone-shaped walkway that puts every plot in reach.

Not surprisingly, the children found that the simulation capability of their computers helped them examine the merits of many different walkway designs. Like modern-day architects, they used the computer to help construct models of their ideas. Teachers Dolores Patton and Leslie Barclay facilitated the process, but it was the children who came up with the ideas.

There are many Life Lab schools in California. Because they are engaged in similar pursuits, they have things to say to one another. For them, networks serve as much more than a conduit for retrieving fixed data; they allow students to develop knowledge of their own collaboratively. For example, it is easy to make one's own weather maps on the basis of simultaneous recordings of temperature and barometric pressure and the like and to argue via network about what the maps mean.

Computer animation can be used to ponder the patterns more readily. A fairly easy inference is that pressure changes seem to go from west to east. Could this have anything to do with the rotation of the earth? The directions of winds are more complicated, since they are more affected by features of the terrain. Do they match up with pressure changes?

We can go still deeper. Children are capable of much depth and attention to quality when they are thinking about questions that seem important to them. Why do animals do what they do? Why do humans do what we do? These are vital issues. Close observation, theories and role-playing help. Reading books about animal behavior helps. The teacher can even explain some ideas of the Nobel laureate Niko Tinbergen, such as the suggestion that animal behavior is organized into modules of innate patterns.

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But these are just words. Now the children can make dynamic models of animal behavior patterns to test Tinbergen's concepts themselves.

Can nine- and 10-year-old children actually capture and understand the mentality of a complex organism, such as a fish? Teacher B. J. Allen-Conn spent several summers learning about intricate ecological relations in the oceans. She searched for ways to express how an individual's behavior is altered by interactions with many other animals. At the same time, Michael Travers, a graduate student from the Media Laboratory at the Massachusetts Institute of Technology who was working with us, built several animal simulations, among them fish behaviors described by Tinbergen. Then Scott Wallace and others in our group turned these various ideas into Playground, a simulation construction kit for children.

Children are particularly enthralled by the clown fish, which exhibits all expected fishlike behaviors (such as feeding, mating and fleeing from predators) but also displays a fascinating way of protecting itself. It chooses a single sea anemone and gradually acclimates to the anemone's poison over a period of several days. When acclimation is complete, the clown fish has a safe haven where it can hide if a predator comes hunting.

It is fairly easy to build a simple behavior in Playground, and so the children produce simulations that reflect how the fish acts when it gets hungry, seeks food, acclimates to an anemone and escapes from predators. Later they can explore what happens when scripts conflict. What happens if the animal is very hungry yet there is a predator near the food? If the animal is hungry enough, will it start eyeing the predator as possible food? Do the fish as a group fare best when each animal is out for itself, or does a touch of altruism help the species overall?

For an adult, the children's work would be called Artificial Intelligence Programming Using a Rule-Based Expert Systems Language. We researchers and the teachers and children see the dynamic simulations as a way of finding out whether theories of animal behavior apply to the real world.

Computers in the Open School are not rescuing the school from a weak curriculum, any more than putting pianos in every classroom would rescue a flawed music program. Wonderful learning can occur without computers or even paper. But once the teachers and children are enfranchised as explorers, computers, like pianos, can serve as powerful amplifiers, extending the reach and depth of the learners.

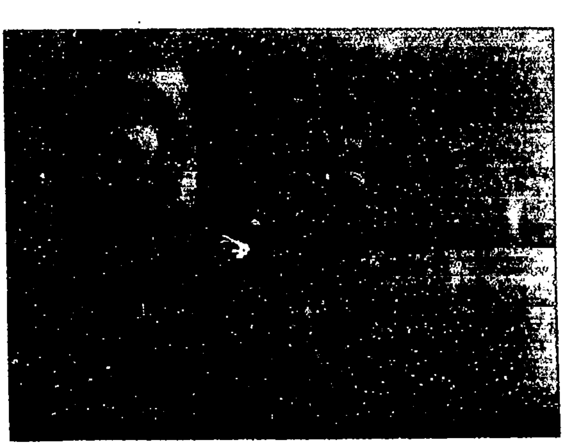
Many educators have been slow to recognize this concept of knowledge ownership and to realize that children, like adults, have a psychological need for a personal franchise in the culture's knowledge base. Most schools force students to learn somebody else's knowledge. Yet, as John Holt, the teacher and philosopher of education, once said, mathematics and science would probably be learned better if they were made illegal. Children learn in the same way as adults, in that they learn best when they can ask their own questions, seek answers in many places, consider different perspectives, exchange views with others and add their own findings to existing understandings.

Ten years from now, powerful, intimate computers will become as ubiquitous as television and will be connected to interlinked networks that span the globe more comprehensively than telephones do today. My group's experience with the Open School has given us insight into the potential benefits of this technology for facilitating learning.

The first benefit is great interactivity. Initially the computers will be reactive, like a musical instrument, as they are today. Soon they will take initiatives as well, behaving like a personal assistant. Computers can be fitted to every sense. For instance, there can be displays for vision; pointing devices and keyboards for responding to gesture; speakers, piano-type keyboards and microphones for sound—even television cameras to recognize and respond to the user's facial expressions. Some displays will be worn as magic glasses and force-feedback gloves that together create a virtual reality, putting the user inside the computer to see and touch this new world. The surface of an enzyme can be felt as it catalyzes a reaction between two amino acids, relativistic distortions can be directly experienced by turning the user into an electron traveling at close to the speed of light.

A second value is the ability of the computers to become any and all existing media, including books and musical instruments. This feature means people will be able (and now be required) to choose the kinds of media through which they want to receive and communicate ideas. Constructions such as texts, images, sounds and movies, which have been almost intractable in conventional media, are now manipulatable by word processors, desktop publishing, and illustrative and multimedia systems.

Third, and more important, information can be presented from many different perspectives. Marvin L. Minsky



EXCERPT FROM A NEWSCLIP is part of a newspaper tailored to the interests of a single individual; the text was produced several years ago by the software program NewsPeek, which the author and Walter Bender designed when they were at the Massachusetts Institute of Technology. The program is an early prototype for one kind of "agent," a system that can learn a user's goals and retrieve relevant information on the person's behalf. Such agents will one day be essential for navigating through the mass of information that will be available on networks.

CHILDREN AT A COMPUTER in the Open School are clearly engrossed in their work. If used properly, the author notes, computers can be "powerful amplifiers, extending the reach and depth of the learners."

of M.I.T. likes to say that you do not understand anything until you understand it in more than one way. Computers can be programmed so that "facts" retrieved in one window on a screen will automatically cause supporting and opposing arguments to be retrieved in a halo of surrounding windows. An idea can be shown in prose, as an image, viewed from the back and the front, inside or out. Important concepts from many different sources can be collected in one place.

Fourth, the heart of computing is building a dynamic model of an idea through simulation. Computers can go beyond static representations that can at best argue; they can deliver sprightly simulations that portray and test conflicting theories. The ability to "see" with these stronger representations of the world will be as important an advance as was the transition to language, mathematics and science from images and common sense.

A fifth benefit is that computers can be engineered to be reflective. The model-building capabilities of the computer should enable mindlike processes to be built and should allow designers to create flexible "agents." These agents will take on their owner's goals, confer about strategies (asking questions of users as well as answering their queries) and, by reasoning, fabricate goals of their own.

Finally, pervasively networked computers will soon become a universal library, the age-old dream of those who love knowledge. Resources now beyond individual means, such as supercomputers for heavy-duty simulation, satellites and huge compilations of data, will be potentially accessible to anyone.

For children, the enfranchising effects of these benefits could be especially exciting. The educator John Dewey noted that urban children in the 20th century can participate only in the form, not the content, of most adult activities; compare the understanding gained by a city girl playing nurse with her doll to that gained by a girl caring for a live calf on a farm. Computers are already helping children to participate in content to some extent. How students from preschool to graduate school use their computers is similar to how computer professionals use theirs. They interact, simulate, contrast and criticize, and they create knowledge to share with others.

When massively interconnected, intimate computers become commonplace, the relation of humans to their information carriers will once again change qualitatively. As ever more information becomes available, much of it conflicting, the ability to critically assess the value and validity of many different points of view and to recognize the contexts out of which they arise will become increasingly crucial. This facility has been extremely important since books became widely available, but making comparisons has been quite difficult. Now comparing should become easier, if people take advantage of the positive values computers offer.

Computer designers can help as well. Networked computer media will initially substitute convenience for verisimilitude, and quantity and speed for exposition and thoughtfulness. Yet well-designed systems can also retain and expand on the profound ideas of the past, making available revolutionary ways to think about the world. As Postman has pointed out, what is required is a kind of guerilla warfare, not to stamp out new media (or old) but to create a parallel consciousness about media—one that gently whispers the debits and credits of any representation and points the way to the "food."

For example, naive acceptance of on-screen information can be combated by designs that automatically gather both the requested information and instances in which a displayed "fact" does not seem to hold.

An on-line library that retrieves only what it is requested produces tunnel vision and misses the point of libraries; by wandering in the stacks, people inevitably find gems they did not know enough to seek. Software could easily provide for browsing and other serendipitous ventures.

Today facts are often divorced from their original context. This fragmentation can be countered by programs that put separately retrieved ideas into sequences that lead from one thought to the next. And the temptation to "clay push," to create things or collect information by trial and error, can be fought by organizational tools that help people form goals for their searches. If computer users begin with a strong image of what they want to accomplish, they can drive in a fairly straightforward way through their initial construction and rely on subsequent passes to criticize, debug and change.

If the personally owned book was one of the main shapers of the Renaissance notion of the individual, then the pervasively networked computer of the future should shape humans who are healthy skeptics from an early age. Any argument can be tested against the arguments of others and by appeal to simulation. Philip Morrison, a learned physicist, has a fine vision of a skeptical world: "...genuine trust implies the *opportunity* of checking wherever it may be wanted.... That is why it is the evidence, the experience itself and the argument that gives it order, that we need to share with one another, and not just the unsupported final claim."

I have no doubt that as pervasively networked intimate computers become common, many of us will enlarge our points of view. When enough people change, modern culture will once again be transformed, as it was during the Renaissance. But given the current state of educational values, I fear that, just as in the 1500s, great numbers of people will not avail themselves of the opportunity for growth and will be left behind. Can society afford to let that happen again?

FURTHER READING

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TOWARD A THEORY OF INSTRUCTION. Jerome S. Bruner. Harvard University Press, 1966.

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AMUSING OURSELVES TO DEATH: PUBLIC DISCOURSE IN THE AGE OF SHOW BUSINESS. Neil Postman. Viking Penguin, 1985.

THE RING OF TRUTH: AN INQUIRY INTO HOW WE KNOW WHAT WE KNOW. Philip Morrison and Phylis Morrison. Random House, 1989.

Chairman WALKER. Thank you, Dr. Kay.
Professor Dede?

STATEMENT OF PROFESSOR CHRIS DEDE, INFORMATION TECHNOLOGY AND EDUCATION, GRADUATE SCHOOL OF EDUCATION, GEORGE MASON UNIVERSITY, FAIRFAX, VIRGINIA

Professor DEDE. I bring you good news and bad news about the future.

The good news is that powerful learning technologies from high performance computing and communications will enable K to 12 schools to move to a new model of education, distributed learning.

Distributed learning is centered on collaborative learning through doing, orchestrated across classrooms and homes and work places and community settings.

America's information infrastructures are the crucial development that makes distributed learning possible, affordable, and sustainable.

Knowledge webs, virtual communities, shared synthetic environments, and sensory immersion are four new technological capabilities shaping distributed learning.

Knowledge webs give students access to experts, archives and shared investigations. As with the worldwide web on the Internet, links between chunks of information will help teachers and learners to interrelate and contextualize ideas.

Virtual communities based on telepresence, the communication of emotion across barriers of distance and time, will encourage and motivate learners.

For example, telementoring and teleapprenticeships will provide both the intellectual and the interpersonal support important in bridging from school to work.

Shared synthetic environments will extend students' experiences by enabling learners and educators at different locations to inhabit and shape a common virtual world.

This offers the possibility of learning through doing in virtual offices, factories, hospitals, and even imaginary environments similar to those on Star Trek's holodeck.

Video game consoles capable of implementing these virtual experiences will be everywhere, even in poor households.

Advances in artificial reality will place students inside virtual worlds with intriguing things to see, hear, and touch. Such sensory immersion is powerful in deepening learners' motivation and their intuitions about physical phenomena.

My current research centers on assessing the potential value of virtual worlds designed to teach material as disparate as electromagnetic fields and intercultural sensitivities.

Using these and other new capabilities for distributed learning is crucial to enhancing the creativity, sophisticated thinking skills, ability to apply ideas, and motivation of K to 12 students.

This is vital for America's future economic well being and for meeting the challenges of citizenship in a knowledge-based society.

Given all these advances, what's the bad news?

The bad news is that technological advances alone are insufficient to leverage educational change.

In 1975, in the early days of microcomputers, accurate forecasts of the extent and power of today's technology would have seemed preposterous. Few would have believed that two decades later, desktop machines, much more powerful than the 1975 supercomputers, would be routinely available in work places, schools, and many homes.

That by 1995, these powerful available technologies would not have completely transformed schooling and learning would have seemed even more incredible. And yet widespread major gains in learning outcomes or motivation have not occurred, even though isolated examples of innovation through educational technology have demonstrated very significant effects.

If all computers and telecommunications were to disappear tomorrow, education would be the least effected of society's institutions.

Those who do not understand history are doomed to repeat it. Three reasons that educational technology has made a limited impact to date are:

First, the major focus of educational technology implementation has been automating marginally effective models of presentational teaching, rather than innovating via new models of learning through doing.

Second, education has been seen as something that happens through teaching students in isolated schooling settings, rather than through empowering and interrelating learning in classrooms, homes, communities, work places, and via the media.

And I would disagree somewhat with the prior two speakers. This is not, these two assumptions are not simply part of the education bureaucracy, these are deeply rooted in our culture, and the educational institutions that have made attempts to go beyond these two assumptions have often been repressed by the communities that they serve because parents and taxpayers and citizens also believe these two limiting things about education.

And third, teachers and school administrators are overwhelmed by their current responsibilities and they do not currently have the support systems necessary to reconceptualize their educational roles.

So in brief, transforming education requires both building a top down computing and communications infrastructure for our society, and developing a second, bottom up human infrastructure of wise designers and educators and parents and citizens.

My written testimony outlines changes in federal policy and federally sponsored research that would help to make this possible.

Thank you for giving me the opportunity to share my ideas.

[The prepared statement of Professor Dede follows:]

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Testimony to the U.S. Congress, House of Representatives, Joint Hearing on Educational Technology in the 21st Century

Committee on Science and Committee on Economic and Educational Opportunities
October 12, 1995

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The development of high performance computing and communications is creating new media, such as the WorldWide Web and virtual realities. In turn, these new media enable new types of messages and experiences; for example, interpersonal interactions in immersive, synthetic environments lead to the formation of virtual communities. The innovative kinds of pedagogy empowered by these emerging media, messages, and experiences are driving a transformation of traditional "teaching by telling" to an alternative instructional paradigm: distributed learning. If the substantial barriers to change discussed later in this testimony are overcome, within two decades American schooling will shift to new models of teaching/learning better suited to developing 21st century workers and citizens for a knowledge-based society.

Implications of New Media for K-12 Education

What does the evolution of new media mean for precollege educators? A medium is in part a channel for conveying content; new media such as the Internet mean that one can readily reach wider, more diverse audiences. Just as important, however, is that a medium is a representational container enabling new types of messages (e.g., sometimes a picture is worth a thousand words). Since the process of thinking is based on representations such as language and imagery, the process of learning is strongly shaped by the types of instructional messages we can exchange with students. Emerging representational containers, such as multimedia, enable a broader, more powerful repertoire of pedagogical strategies.

The global marketplace and the communications and entertainment industries are driving the rapid evolution of high performance computing and communications. Regional, national, and global information infrastructures are developing that enhance our abilities to sense and act and learn across barriers of distance and time; within two decades, the process of building these physical and technical infrastructures will be complete. How information is created, delivered, and used in business, government and society is swiftly changing. In the future, to successfully prepare students as workers and citizens, teachers will incorporate into the school curriculum experiences with creating and utilizing new forms of expression, such as virtual reality. Information infrastructures will provide channels for delivering such technology-intensive learning experiences just-in-time, anyplace, and on-demand, enabling partnerships for effective K-12 education among schools, parents, businesses, communities, and the media.

Many people are still reeling from the first impact of high performance computing and communications: shifting from the challenge of not getting enough information to the new challenge of surviving too much information. In a few years, the core skill for American workplaces will not be foraging for data, but filtering and synthesizing a plethora of incoming information. The new type of literacy students must master will require diving into a sea of information, immersing oneself in data to harvest patterns of knowledge just as fish extract oxygen from water via their gills. Understanding how to structure learning experiences to make such immersion possible will be the core of the new rhetoric. Expanding traditional definitions of literacy and rhetoric into immersion-centered experiences of interacting with information will be central in schools preparing K-12 students for full participation in 21st century society.

Emerging forms of distributed learning are empowering the reconceptualization of K-12 education's mission, process, and content. This new instructional paradigm is based both on shifts in what learners need to be prepared for the future and on additional capabilities information technology is adding to the pedagogical repertoire of teachers. By 2015, at least four new forms of expression will shape the emergence of distributed learning as American schools' primary pedagogical model:

- knowledge webs will complement teachers, texts, libraries, and archives as sources of information;
- interactions in virtual communities will complement face-to-face relationships in classrooms;
- experiences in synthetic environments will extend learning-by-doing in real world settings; and
- sensory immersion will help learners grasp reality through illusion.

We are just beginning to understand how these representational containers can reshape the content, process, and delivery of conventional classroom education. Information infrastructures are the lever for this evolution, just as the steam engine was the driver for the industrial revolution.

Knowledge Webs

In two decades, "knowledge webs" will routinely enable K-12 students distributed access to experts, archival resources, authentic environments, and shared investigations. Via information infrastructures, educators and pupils will regularly join distributed conferences that provide an instant network of contacts with useful skills, a personal brain trust with just-in-time answers to immediate questions. In time, these informal sources of expertise will utilize embedded "groupware" tools to enhance collaboration. Even on today's Internet, on-line archival resources are increasingly linked into the WorldWide Web, accessible through "webcrawlers" such as Mosaic™ and Netscape™. In the future, artificial intelligence-based guides and filters will facilitate learners navigating through huge amounts of stored information.

Virtual exhibits that duplicate real-world settings (e.g., museums) will form the basis of most field trips; these environments make possible a wide variety of experiences without the necessity of travel or scheduling. Distributed science projects will enable conducting shared experiments dispersed across time and space, each team member learning more than would be possible in isolation about the phenomenon being studied and about scientific investigation.

However, access to data does not automatically expand students' knowledge, nor will the mere availability of information intrinsically create an internal framework of ideas that learners can apply in real world settings. While presentational approaches transmit material rapidly from source to student, often this content evaporates quickly from learners' minds. To be motivated to master concepts and skills, precollege students need to see the connection of what they are learning to the rest of their lives and to the mental models they already use. Helping students progress from access through assimilation to appropriation requires educational experiences that empower knowledge construction by unsophisticated learners, aiding them in making sense of massive, incomplete, and inconsistent information sources. As part of using knowledge webs, to move students beyond assimilating inert facts into generating better mental models, teachers will structure learning experiences that highlight how new ideas can provide insights in intriguing, challenging situations.

In two decades, a vital form of literacy that educators will communicate is how to transform archival information into personal knowledge. Access to knowledge webs on information infrastructures will provide powerful ways of accomplishing that instructional goal. However, to leverage this access into better educational outcomes, classrooms will incorporate sophisticated learning-through-doing strategies so that learners can interpret the data they receive.

Virtual Communities

Two decades hence, virtual communities that provide support from others who share common joys and trials will also enhance distributed learning in American schools. We are accustomed to face-to-face interaction as a means of getting to know people, sharing ideas and experiences, enjoying others'

humor and fellowship, and finding solace. In the future, distributed learning via information infrastructures will satisfy many of these needs at any time, any place. Some students (shy, reflective, comfortable with emotional distance) even find asynchronous, low bandwidth communication more "authentic" than face-to-face verbal exchange. They take time before replying to carefully compose a message, as well as to refine the emotional nuances they wish to convey. This alternative conception of personal authenticity may help us understand how better to tailor instruction for diverse learning styles.

Within two decades, K-12 educators will use the virtual communities information infrastructures make possible to dramatically improve learning outcomes. Learning is social as well as intellectual; individual, isolated attempts to make sense of complex data can easily fail unless the learner is encouraged by some larger group that is constructing shared knowledge. Virtual communities enable new pedagogical strategies that facilitate such encouragement and motivation. For example, peer tutoring aids all students involved both intellectually and emotionally, but has been difficult to implement in traditional classroom settings. In the future, virtual interactions will readily enable such student-student relationships outside of school, as well as preparing their participants for later use of distributed problem solving techniques in adult workplace settings. Telementoring and teleapprenticeships between students and workplace experts will be similar examples of applying virtual community and "groupware" capabilities to distributed learning.

In addition, educators themselves need emotional and intellectual support from others who have similar challenges in their lives. In the future, virtual communities will provide a means of helping teachers find the strength to help schooling keep pace with our rapidly changing and increasingly diverse society.

Moreover, formal education comprises only a small fraction of how students spend their time. No matter how well schooling is done, achieving major gains in learning requires that the rest of pupils' lives be educationally fulfilling as well. This necessitates close cooperation and shared responsibility for distributed learning among society's educational agents (families, social service agencies, workplaces, mass media, schools, higher education). By 2015, virtual communities will routinely enhance this collaboration among stakeholders in quality education. For example, involving families more deeply in their children's education may be the single most powerful lever for better learning outcomes. Virtual parent-teacher conferences and less formal social interchanges will make such involvement more likely for parents who would never come to a PTA meeting or a school-based event.

This future is prefigured today in many regions across America, as community networks are emerging that enhance education by enabling distributed discourse among all those concerned with improving schooling. However, the completely virtual school will never be practical, as face-to-face interactions will continue to be important in fulfilling schools' educational, socialization, and custodial responsibilities.

Shared Synthetic Environments that Complement Real World Experiences

Two decades from now, another capability for enhancing distributed learning will be shared synthetic environments that extend students' experiences beyond what they can encounter in the real world. Information infrastructures are not only channels for transmitting content, but also virtual worlds that students can enter and explore. Just as single-user simulations allow an individual to interact with a model of reality (e.g., flying a virtual airplane), distributed simulations enable many people at different locations to inhabit and shape a common synthetic environment. For example, the U.S. Department of Defense today uses distributed simulation technology to create virtual battlefields on which learners at remote sites develop collective military skills. The appearance and capabilities of graphically represented military equipment alter second-by-second as the virtual battle evolves.

In the future, distributed simulation will be a representational container that can empower a broad range of educational uses (e.g., virtual factories, hospitals, cities). The vignette below depicts a hypothetical future application that promotes distributed learning outside the classroom through "edutainment."

Roger was unobtrusively sidling across the Bridge of the Starship Enterprise when the Captain spotted him out of the corner of his eye. "Take the helm, Ensign Pulver," growled Captain Jean-Luc Picard, "and pilot a course through the corona of that star at lightspeed 0.999. We have astrophysical samples to collect. You'll have to guard against strange relativistic effects at that speed, but our shields cannot stand the radiation flux we would experience through traveling less quickly." Roger had intended to sneak onto the Ecology Deck of the Starship and put in a little work on his biology class project in controlling closed-system pollution levels, but no such luck. Worse yet, he suspected that the Vulcan communications officer watching him while she translated a message in French was in fact the "avatar" *(computer-graphics representation of a person)* of a girl he admired who sat three rows behind him in his languages class. Of course, he could be wrong; she might be someone teleporting into this simulation from who knows where or could even be a "knowbot" *(a machine-based simulated personality used to simplify the job of instructors directing an instructional simulation).*

Buying a little time by summoning up the flight log, Roger glanced curiously around the bridge to see what new artifacts his fellow students had added since yesterday to this MUD *(Multi-User-Dungeon or Dimension, a current type of adventure game in which participants mutually evolve an elaborate, shared synthetic environment by continuously modifying its contents).* In one corner, an intriguing creature was sitting in a transparent box, breathing a bluish-green atmosphere—maybe this was the long-awaited alien the anthropology and biology majors were creating as a mutual project. The 3-D goggles from his Nintendo++ set intensified the illusion that the lizard-like countenance was staring right at him...

"Impulse Engines to full speed, Mister," barked Captain Picard! "This Mage *(human expert guiding the evolution of a virtual environment)* seems rather grumpy for a regular teacher," thought Roger, "maybe he's a visiting fireman from the new Net-the-Experts program." On his Console, Roger rapidly selected equations that he hoped would yield the appropriate relativistic corrections for successfully navigating through the star's corona. He hoped to impress Captain Picard as a means of improving his chances for promotion. Last week's setback, getting motion sick while "riding" on a virtual gas molecule that was illustrating Brownian motion, had not helped his chances...

This vignette shows how by 2015 education could be situated in a synthetic universe analogous to a authentic real-world environment, but more intriguing. Moreover, such a distributed learning strategy would leverage a huge installed base of sophisticated information technology—home videogame consoles—as well as the substantial motivation inculcated by the entertainment industry. In the future, videogame consoles will provide sophisticated platforms for implementing such visually-based distributed learning technologies and will be ubiquitous even in poor and rural households.

Sensory Immersion to Grasp Reality Through Illusion

In addition to distributed simulation, within two decades advances in high performance computing and communications will also enable learners' sensory immersion in "artificial realities." Via an immersion interface based on computerized clothing and a head-mounted display, the student will feel "inside" an artificial reality rather than viewing a synthetic environment through a computer monitor's screen; virtual reality is analogous to diving rather than looking into an aquarium window. Scientific data visualization research has already established that using sensory immersion to present abstract, symbolic data in tangible form is a powerful means of attaining insights into real world phenomena.

For example, "visualization" is an emerging type of rhetoric that enhances learning by using the human visual system to find patterns in large amounts of information. People have very powerful pattern recognition capabilities for images; much of our brain is "wetware" dedicated to this purpose. As a result, when tabular data of numerical variables such as temperature, pressure, and velocity are transfigured into graphical objects whose shifts in shape, texture, size, color, and motion convey the changing values of each variable, increased insights are often attained. For example, graphical data visualizations that model thunderstorm-related phenomena (e.g., downbursts, air flows, cloud

movements) are valuable in helping meteorologists and students understand the dynamics of these weather systems.

In the future, when information infrastructures routinely allow people to access large databases across distance, visualization tools will expand pupils' perceptions so that they recognize underlying relationships that would otherwise be swamped in a sea of numbers. One good way to enhance creativity is to make the familiar strange and the strange, familiar; adding sonification and even tactile sensations to visual imagery will make abstract things tangible and vice versa. For example, expanding human perceptions (e.g. allowing a medical student—like Superman—to see the human body througn X-ray vision) is a powerful method for deepening learners' motivation and their intuitions about physical phenomena. My current research centers on assessing the potential value of sensory immersion and synthetic environments for pre-college students learning material as disparate as electromagnetic fields and intercultural sensitivities.

The vignette below illustrates how sensory immersion might someday be combined with knowledge webs, virtual collaboration, and synthetic environments to enable powerful forms of distributed learning.

COLLABORATIVE TRAINING IN A SHARED SYNTHETIC ENVIRONMENT

Karen sat down at her educational workstation, currently configured as an electronics diagnosis/repair training device. When sign-in was complete, the workstation acknowledged her readiness to begin Lesson Twelve: Teamed Correction of Malfunctioning Communications Sensor. Her "knowbot" *(machine-based agent)* established a telecommunications link to Phil, her partner in the exercise, who was sitting at a similar device in his home thirty miles away. "Why did I have the bad luck to get paired with this clown?" she thought, noting a hung-over expression on his face in the video window. "He probably spent last night partying instead of preparing for the lesson." A favorite saying of the problem solving expert to whom she was apprenticed flitted through her mind, "The effectiveness of computer-supported cooperative work can be severely limited by the team's weakest member."

"Let's begin," Karen said decisively. "I'll put on the DataArm to find and remove the faulty component. You use the CT (cognitive transducer) to locate the appropriate repair procedure." Without giving him time to reply, she put on her head-mounted display, brought up an AR *(artificial reality)* depicting the interior of a TransStar communications groundstation receiver, and began strapping on the DataArm. The reality-engine's meshing of computer graphics and video images presented a near-perfect simulation, although too rapid movements could cause objects to blur slightly. Slowly, she "grasped" a microwrench with her "hand" on the screen and began to loosen the first fastener on the amplifier's cover. Haptic feedback from the DataArm to her hand completed the illusion, and she winced as she realized the bolt was rusty and would require care to remove without breaking.

Meanwhile, Phil called up the CT for Electronics Repair; on the screen, a multicolored, three-dimensional network of interconnections appeared and began slowly rotating. He groaned; just looking at the knowledge web made his eyes hurt. Since the screen resolution was excellent, he suspected that last night's football party was the culprit. Phil said slowly, "Lesson Twelve," and a trail was highlighted in the network. He began to skim through a sea of stories, harvesting metaphors and analogies, while simultaneously monitoring a small window in the upper left-hand corner of the screen that was beginning to fill with data from the diagnostic sensors on Karen's DataArm.

Several paragraphs of text were displayed at the bottom of the screen, ignored by Phil. Since his learning style is predominantly visual and auditory rather than symbolic, he listens to the web as it vocalizes this textual material, watching a graphical pointer maneuver over a blueprint. Three figurines are gesturing near the top of the display, indicating that they knew related stories. On the right hand side of the monitor, an interest-based browser shows index entries grouped by issue, hardware configuration, functional system, diagnostic symptoms, and potential causes.

Traversing the network at the speed with which Karen was working was difficult, given his

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tiredness, and he made several missteps. "Knowledge Base," Phil said slowly, "infer what the optical memory chip does to the three-dimensional quantum well superlattice." The voice of his knowbot suddenly responded, "You seem to be assuming a sensor flaw when the amplifier may be the problem." "Shut up!" Phil thought savagely, hitting the cut-off switch. He groaned when he visualized his knowbot feeding the cognitive audit trail of his actions into the workstations of his teacher and the communications repair expert serving as his business mentor; he could not terminate those incriminating records. Phil cringed when he imagined his teacher's "avatar" giving him another lecture on his shortcomings. Mentally, he began phrasing an elaborate excuse to send his instructors via video teleconferencing at the termination of this disastrous lesson.

Meanwhile, Karen was exasperatedly watching the window on her AR display in which Phil's diagnostic responses should have been appearing. "He's hopeless," she thought. Her knowbot's "consciousness sensor" *(a biofeedback link that monitors user attention and mood)* interrupted with a warning: "Your blood pressure is rising rapidly; this could trigger a migraine headache." "Why," Karen said sadly, "couldn't I have lived in the age when students learned from textbooks..."

Young people like magical alternate realities; and today's entertainment industry profits by providing amusement parks, videogames, movies, and television programs that build on this fascination. By 2015 educators too will profit, in a different way, through building eerily beautiful environments for sensory immersion that arouse curiosity and empower shared fantasy, leading to learning via guided inquiry.

In addition to knowledge webs, virtual communities, synthetic environments, and sensory immersion, the generation growing up with high performance computing and communications will invent many uses for sophisticated information technologies, applications difficult for us to imagine today. Providing these K-12 students the type of schooling that encourages creativity, curiosity, and the desire to continue learning is vital to America's future economic well-being. Imagining civilization two decades from now may be as difficult for us today as visualizing a commodities broker electronically monitoring soybean options would have been for eighteenth century farmers contemplating a steam tractor. America doesn't have much time to understand and shape what is happening; the Industrial Revolution took more than a century to reach fruition, but global economic competition and the pace of technological advance will drive the next transformation much more quickly. Examining how workforce skills are changing today can aid in comprehending why transforming industrial-age approaches to schooling is vital for our future prosperity—as well as empowering the other important purposes of education beyond preparing learners for employment.

Information Technologies Are Creating a Knowledge-Based Economy

In the past, graduates of K-12 schooling were prepared to compete effectively with other Americans in our domestic economy. However, the evolution of worldwide markets based on high performance computing and communications means that U.S. employers and employees must be more adept than their global competitors at meeting the needs of a very diverse range of customers. In this new economic "ecology," each nation is seeking a range of specialized niches based on its financial, human, and natural resources. Developed countries, which no longer have easily available natural resources and cheap labor, have difficulty competing with rising-star developing nations in manufacturing standardized industrial commodities. However, America is utilizing her strengths (technological expertise, an advanced industrial base, an educated citizenry) to develop an economy that uses sophisticated people and information tools to produce customized, value-added products.

Two opposite types of information technologies are now reshaping the workplace: smart machines and intelligent tools. Smart machines take control of the job, telling the worker what to do next; one example is the automated devices that guide medical technicians through analyzing blood samples. In contrast, intelligent tools provide workers with powerful capabilities to be utilized as they choose; an illustration is a graphic artist using a computerized animation program to create a cartoon. One way of understanding the impact of these two types of workplace devices on workers' occupational skills is to contrast how information technology has changed the job roles of the supermarket checker and the typist. Many supermarkets now have bar code readers; rather than finding the price on each item and

punching it into the register, the checker needs only to pass the goods over the scanner. Efficiency and productivity have increased, but the food you buy tastes the same as before, and less skills are needed to do the job. Smart machines tend to increase efficiency, but also deskill jobs, lower salaries, and make work more mechanical—the person becomes the eyes, arms, and personality for a device that does the recording, storing, "thinking," and decision making.

In contrast, substituting a office automation system for a typewriter requires a secretary to function in more sophisticated ways. To use the information tool for customizing a mass of data to the individual needs of recipients, the clerical role must shift from keyboarding to utilizing database, desktop publishing, and groupware applications. The job now demands higher-order cognitive skills to extract and tailor knowledge from the enormous information capacity of the tool, and the occupational role shifts to the new profession of information manager. Intelligent tools increase effectiveness rather than efficiency; new, more skilled roles are created that pay higher salaries.

America's niche in the global economy—customized, value-added products—necessitates a shift in work roles away from smart machines manufacturing standardized commodities toward cognitive partnerships with intelligent tools. As this transformation to a post-industrial economy occurs, an evolution of job requirements toward higher-order thinking skills is taking place in all types of occupations, blue-collar as well as white-collar. By 2015, people's creativity and flexibility will be vital as job skills, because the standardized aspects of problem solving will be increasingly absorbed by machines.

American schooling must alter its focus to prepare learners for cognitive partnerships with intelligent tools. Until the need for these new types of skills is routine in workplace settings, shifting the emphasis of education is difficult for society to initiate—but by then a generation of our workers will be ill-prepared to compete in the global economic arena. The core challenge is to prepare today's students for a future workplace more disparate from present experience than at any time since the Industrial Revolution. Fortunately, sophisticated information technologies can provide the leverage to make evolution to a new educational model possible; the same advances that are transforming the economy can empower new models of teaching/learning. However, for a transfiguration of K-12 schooling to occur, profound barriers that have nothing to do directly with technology must be overcome.

Overcoming Barriers to A Transformation of Schooling

In 1975, in the early days of microcomputers, accurate forecasts of the extent and power of today's educational technology would have seemed preposterous to the business sector, technologists, and educators. Few would have believed that two decades later desktop machines much more powerful than supercomputers at that time would be routinely available in workplaces, schools, and many homes, with sophisticated applications and high speed networking/telecommunications.

Assume that someone had convinced them such a forecast was accurate. That these powerful, available technologies would not have completely transformed schooling and learning would have seemed even more incredible. And yet, widespread major gains in learning outcomes or motivation have not occurred, even though isolated examples of innovation have demonstrated very significant effects. If all computers and telecommunications were to disappear tomorrow, education would be the least affected of society's institutions.

The next two decades will likely see comparable increases in the power and dissemination of computers and telecommunications. Those who do not understand history are doomed to repeat it. What lessons can we learn from our experience to prevent a comparable lack of impact on educational outcomes from again occurring?

Understanding the Problem

Economic and technical barriers to change, while significant, are not the primary problems; by shifting how current resources are allocated, educational institutions can deploy and utilize powerful technologies. A lack of evidence on effectiveness is also not the major barrier to transforming schools with the help of technology, even though more studies and better methodologies would be useful.

Research documenting the utility of educational technology has been widely disseminated without inducing substantial changes in practice.

Five major reasons that educational technology has made a limited impact to date are:

- Education has been seen as something that happens through teaching students in isolated schooling settings, rather than through empowering and interrelating learning in homes, classrooms, communities, workplaces, and via the media.
- The major focus of educational technology implementation so far has been automating marginally effective models of presentational teaching, rather than innovating by making more effective models of learning-through-doing affordable and sustainable.
- Psychological, organizational, political, and cultural barriers from every type of stakeholder in education (students, teachers, administrators, parents, business, universities, accrediting associations) have impeded implementing educational innovations that undercut traditional models of pedagogy, content, assessment, and institutional organization.
- Cost and productivity calculations for educational technology have largely been framed in the limited context of a budget for schooling (e.g., dollars divided by students), rather than assessed against the larger economic context of human resource issues in our society (i.e., international competitiveness, workforce productivity, costs of crime and welfare, more complex responsibilities for citizens).
- Teachers and school administrators are overwhelmed by their current responsibilities and do not have the support systems necessary to enable reconceptualizing their role to enable learning with the aid of technology.

This situation is parallel to similar shortfalls in expected outcomes from the initial implementation of computers in business. However, educational institutions do not face the same types of pressures to move beyond impediments to innovation that businesses do. As a result, schools are stagnating at a time when our country urgently needs skilled workers and citizens for a knowledge-based society.

What actions should the U.S. Congress take to create a climate for innovation and experimentation that undermines these barriers to improving education? What are the roles of educational research and of federal policy in resolving gridlocks constraining effective usage of educational technology?

Creating a Climate for Innovation and Experimentation

As the five barriers above suggest, the largest impediment to effective use of new technologies for learning is the outmoded paradigm of education deeply rooted in our culture. Using the stature of the U.S. Congress as a vehicle to aid people in evolving their mental models of teaching and learning involves many strategies, including:

- helping parents recognize that changes they see in their current workplace—new types of career paths, shifts in the skills and knowledge most valued by employers—have dramatic implications for the education of their children;
- helping teachers who feel frustrated by the rigid structure of conventional classrooms to envision alternative forms of instruction that enable more fulfilling relationships with pupils;
- helping the corporate sector to see that the employee attitudes most valuable for the knowledge-based workplace are best inculcated through learning partnerships among parents, communities, businesses, the media, and schools;
- helping groups with sometimes opposing goals (e.g., school administrators, teachers' unions) to work together toward technology-based educational innovation as a win/win situation;
- helping taxpayers to realize that, in a knowledge-based economy and democracy, individuals can realize the American Dream only when all members of our society realize their full capabilities to contribute to the common good; and

- helping citizens understand that the most dangerous experiment we can conduct with our children is to keep schooling the same when every other aspect of our society is dramatically changing.

Vital in creating this climate for educational innovation and experimentation is that the federal government "walk its talk" by exemplifying leading edge goals, curriculum standards, and strategies for technology-based reform in the educational programs it manages (e.g., the Job Corps).

Shifting the Emphasis of Educational Research

Educational research can provide vital knowledge for informed, reflective innovation and experimentation. At least two types of studies on educational technology are currently underfunded:

- research on active, collaborative strategies for learning based on real world problems
- research on empowering and interrelating learning in multiple settings

Altering the thrust of current federal research initiatives is one means of funding such studies even during this time of tight fiscal resources. We must shift from analyzing our current, marginally effective instructional paradigm to synthesizing and evaluating emerging models of new educational approaches.

Research on active, collaborative, problem-centered strategies for learning (e.g., teleapprenticeships) is crucial to developing and assessing new types of technology-based applications for schools. For example, I and my colleagues are studying how virtual reality can enhance learning in fields as varied as physics and anthropology. As discussed earlier, a decade from now the largest installed base of sophisticated information technology available to learners will be home videogames, which will then have the capabilities of today's high-end engineering workstations and will be ubiquitous even in poor and rural households. Using this resource external to classrooms as a delivery mechanism for motivating learning-through-doing experiences could enrich students' lives both inside and outside of school. However, with recent budgetary cuts, the only sources of funding for these studies and other research on new models for technology-based learning are the small Applications of Advanced Technology Program in the National Science Foundation and limited resources from the U. S. Department of Defense Advanced Research Projects Agency. This stands in sharp contrast to relatively large amounts of federal resources provided for other emerging application areas in high performance computing and communications and for the National Information Infrastructure.

Research on empowering and interrelating learning in multiple settings is also critical and similarly underfunded. As discussed earlier, the increasing bandwidth of communications networks is enabling "telepresence," the ability to add an affective dimension to the exchange of information across barriers of distance and time. As a result, virtual relationships and communities are forming among people who share ideas and experiences via new media such as the Internet. Virtual communities are potentially a powerful force for aiding educational restructuring and reform, which depends on widely scattered stakeholders forming common bonds of commitment and trust. However, only a few small federal programs in the U.S. Departments of Education and Commerce and in the National Science Foundation are funding the development and evaluation of projects building virtual bridges among groups that could collaboratively enhance students' learning. In particular, resources are needed for developing sophisticated evaluation methodologies capable of handling problems of scale and interacting variables intrinsic in this type of educational research.

The important emphasis in these two areas of study is on formative assessments that emphasize understanding educational problems, developing evolving solution strategies, and relating outcomes to the nation's overall challenges in human resource development. Such an approach is much more useful than conducting summative evaluations of educational technology that seek final measures of cost-effectiveness or productivity only from the narrow perspective of a fixed schooling or training budget. Educational technology is expanding its capabilities too rapidly for static measures of mature innovations to be useful, so federal funding for educational research should alter to emphasis formative development and evaluation.

One major barrier to educational change is that, despite the rich "lessons learned" in many diverse school-based technology projects, no systematic mechanism exists for sharing ideas or providing

information on issues as basic as how to design and implement viable projects, what technology and financing options are available, and how to overcome common problems and barriers. Because guidebooks, proven strategies, and resources that could help them find their way are not readily available, educators who are interested in using technology to improve learning often needlessly feel like pioneers in the wilderness. For those who are not interested in technology--or who are already overwhelmed by the challenges of numerous other problems besetting their institutions--this lack of information and encouragement prevents technology from being part of the solution. The federal government should champion establishing a non-profit resource center whose mission is to improve the quality of schooling and lifelong learning in this country by facilitating the use of National Information Infrastructure technologies. If formed through combined public/private sector initiatives, such a center for learning and technology could collect and generate useful information, deliver innovative support services, and proactively reach out to communities who need assistance.

Reassessing Federal Policies that Implicitly Undercut Educational Innovation

Federal policies that on the surface seem unrelated to educational technology can have a negative effect on its development. Any federal action or regulation that indirectly constrains educational innovation via locking out alternative models of teaching/learning or of school management can severely hamper educators' abilities to use innovative technologies. Policies that have this impact include those that:

- isolate classrooms and schools from other learning settings in society
- automate traditional models of schooling with fifty minute periods and separate disciplines
- evaluate only educational outcomes readily developed by conventional "teaching by telling"
- omit a technological infrastructure in providing support for school reform
- sanction groups that accredit educational institutions by applying only traditional models of curriculum and instruction

An informal "impact assessment" of all federal policies related to education is needed to identify actions and regulations that implicitly stifle innovative uses of technology through emphasizing traditional, marginally effective approaches to schooling. Similarly, federally managed schools, such as the U.S. Department of Defense Education Activities, should exemplify leading edge approaches to educational reform through technology. Finally, as vital resources such as access to wireless bandwidth are distributed by the federal government, allocating sufficient capacity for a twenty-first century educational system is crucial.

Conclusion

Information technologies are more like clothes than like fire. Fire is a wonderful technology because, without knowing anything about how it operates, you can get warm just standing close by. People sometimes find computers, televisions, and telecommunications frustrating because they expect these devices to radiate knowledge. But all information technologies are more like clothes; to get a benefit, you must make them a part of your personal space, tailored to your needs. New media complement existing approaches to widen our repertoire of communication; properly designed, they do not eliminate choices or force us into high tech, low touch situations.

How a medium shapes its users, as well as its message, is a central issue in understanding distributed learning in K-12 schools. The telephone creates conversationalists; the book develops imaginers, who can conjure a rich mental image from sparse symbols on a printed page. Some television induces passive observers; other shows, such as Sesame Street and public affairs programs, can spark users' enthusiasm and enrich their perspectives. High performance computing and communications are creating new interactive media capable of great good or ill. Unless we apply innovative policies to shape the NII's evolution, today's "couch potatoes," vicariously living in the fantasy world of television, could become tomorrow's "couch funguses," immersed as protagonists in 3-D soap operas while the real world deteriorates. The most significant influence on education will not be the building of a ubiquitous, top-down computing and communications infrastructure for our society; but the development of a second, bottom-up human infrastructure of wise designers, educators, and learners.

Chairman WALKER. Thank you very much.
Dr. Shaw?

STATEMENT OF DR. DAVID E. SHAW, D.E. SHAW & COMPANY, NEW YORK, NEW YORK

Dr. SHAW. Thank you.

I'm deeply honored to be here, and also very excited. Honored because of my chance to address this body, but also very excited because I sense a confluence of interest in this area which has been important to us for a long time now, both in the legislative branch now, and in the executive branch.

And also within the educational community and the educational research community and educational technology research community. And this makes me think that something's actually likely to happen which is going to be very important for us over the years.

I'm delighted to see Congress' interest. I want to make sure everyone knows that the White House is also very seriously interested.

I've had the honor of serving as President [1] of the Panel on Educational Technology of the President's Committee of Advisors on Science and Technology, which has first of all brought me in contact with some of the people in the White House and in the Department of Education, who are doing some remarkable work in this area.

But also, and in some ways more important, brought me in contact with a number of the people out there who've been doing research and practicing in this area for a long time. And all of us, I think, have the sense that with bipartisan support, something important could happen now.

What that importance actually is, I think, and I'll be echoing what all three of the speakers have said so far, has probably 20 percent to do with technologies and 80 percent to do with what we do with those technologies.

Because we haven't said much about that, and I sense that there may be some interest in it, let me just sketch the quick future sketch of what may happen. But I'm going to do it very quickly, partly because of time limitations, and partly because I think you've heard this so many times that the words will start to sound like obviosities.

The first one is computing speed and power and memory capacity is going to go up dramatically over the next 20 years. We don't know exactly how fast because there could be unforseen obstacles and unforseen discoveries. But if I had to guess, I would guess that we'll have about 100 times the computing speed and memory capacity for an equivalent price by the year 2015.

On the low end, we can expect to see the computing and memory resources that you'd find in the most powerful personal computer or work station, selling for well under a hundred dollars, where the dominant cost is likely to be the actual I/O devices, the display devices, and data entry devices.

[1] Dr. Shaw's correct title is Chairman of the Panel on Educational Technology of the President's Committee of Advisors on Science and Technology.

And what that means is that when those costs dominate, we'll have to look to new technologies like, for example, set-top tv boxes, or hand-held devices where we can get the cost down low enough that we can exploit the very low cost computing power.

We're also going to see dramatically increased communications bandwidth. The most obvious part of that is the Internet which has caught the public's attention in the last year.

My hope there is that we'll see Internet access become ubiquitous or nearly ubiquitous, and I'm particularly concerned with whether that's going to reach people in rural communities, in the inner cities, in some of the areas that if we're not carefully looking at, are likely to fall victim to being part of a bimodal distribution of information haves and have-nots, and where we could actually exacerbate some of the problems that are besetting our communities right now rather than help them.

But assuming we do have that, electronic mail is going to become nearly ubiquitous, at least for anyone with access to a computer. We'll expect to see that be at least as common as fax machines and fax numbers, and possibly even approaching telephones, and other sorts of communications should be made possible by the fact that we'll now be able to transmit not just short textual messages, but full motion video and high quality audio.

In short, we'll be able to communicate in all the ways that we're used to doing, but over large geographical distances.

Now what does this actually mean to us?

Actually, I think what it means as it really comes from an enabling technology and not from being central. If we focus too much on the raw technologies, even on such important things as connecting people to the Internet, or getting a computer in every home, we may wind up in a situation where we have technology that's not being used at all, much less being effectively used.

There are some things that are very important about computer-based technologies in education. One of the simplest ones, and one of the ones we learned about even in very early drill-and-practice-based, systems was that you could individualize instruction.

Students could learn on a self-paced basis so that rather than having the teacher focus on some hypothetical "typical" student, and then leave behind some of the students in the class, and have other ones be profoundly bored and have their attention wander, the student could basically find his own pace or her own pace and learn things that wouldn't otherwise be learned.

Different modes of learning—visual learning, verbal learning and textual learning—which are idiosyncratic to individual students are also supported by these technologies. But I think the most important kinds of changes that can be supported by these new technologies really have to do with entirely new modes of learning.

And if I had to summarize those, just based what I've learned in the past few months on the Panel, I'd say the most important thing is that the student would assume a central role as the active architect of his or her own knowledge and skills, rather than passively absorbing information that's proffered by a teacher who is sitting in the front of the classroom.

The second thing would be that basic skills wouldn't be learned in isolation, but in the course of undertaking various higher world

tasks and integrating a number of basic skills in the course of solving these real world problems. Information resources would also be key, but the importance of that really comes from having the student be able to access those when they're really needed to solve real problems rather than have a forced centralized curriculum.

I'd also expect to see fewer topics covered than is the case with the traditional sort of paradigm in education, but with those topics explored in more depth in a very student-directed way.

And finally, greater attention is likely to be given to the acquisition of higher-order thinking and problem-solving skills, with less of an emphasis on the assimilation of large body of isolated facts.

And that really represents a transformation in education itself. The use of technology there is profoundly important, but the role of the human beings who are participating in this process is also going to be transformed, in part because of technology, but in part, they will transform the way technology is used.

Teachers will still be important. And for those of us who are expecting that we'll have an increase in productivity because aggregate teacher compensation will drop because computers will take over their jobs, that's not likely to actually happen.

I think what's much more likely is that the teacher will become a coach, a monitor—walking around the classroom, seeing what the individual students are doing, helping out in a very different role than before.

The other thing that I think is going to be important is involving parents and the community in technology, particularly to the extent that we have access in the home. If parents can communicate better with teachers, if teachers can communicate better with each other, and if the community can be tied together, we're going to see repercussions not just for the community but for the quality of education.

As far as how we get there, I think this group and Congress in the large is going to have a major influence on whether it happens and how it happens.

Unfortunately, some part of that has to do with spending. We're now spending about 1.3 percent of the education budget on technology. Best estimates are it will take three to five percent, depending on exactly what we do.

And what's more, the federal government now spends a disproportionate share of its education budget on technology. So if that's cut down, what we're going to see is much less technology in the schools.

Even more important is research and evaluation. And that's particularly important because, first of all, we don't know what kinds of educational technologies work, and secondly, there's an economic externality. There's a good theoretical reason to believe that if this sort of research is not funded at the federal level, it won't be done.

The reason is that if a private company does it, it won't be able to appropriate the full returns from its investment.

If you develop a software product for education and it works, your competitors copy it, and your investment winds up dissipated among all of your competitors.

We could do it at the state and local levels, but we'd have a similar free-rider problem.

In short, there's much that we have to do. Much of it has to be done at the federal level, and I hope we do that.

[The prepared statement of Dr. Shaw follows:]

Technology and the Future of Education

Testimony Prepared for the Joint Hearing of the House Committee on Science and the House Committee on Economic and Educational Opportunities on "Educational Technology in the 21st Century"

by

David E. Shaw, Ph.D.

My wife and I are expecting our first child eleven days from today. If all goes according to plan, we will be providing her with siblings over the next few years to keep her company, and one or more of them will probably be attending high school in the year 2015. It is important to us, as it is to many Americans, that our children obtain the education they will need to play a meaningful role within what will then be a more tightly integrated global community and a more highly competitive world economy. The question of how American education will be transformed by technology over the next twenty years is thus of interest to me not only as a computer scientist, former professor, and high-tech investor, but as a prospective parent and concerned citizen as well.

The value of my testimony will necessarily be limited in important respects both by my lack of formal training and actual experience in the teaching of primary and secondary school students and by the intrinsic difficulty of projecting two decades hence on the basis of current knowledge and current technologies. In the context of my current responsibilities as chairman of the Panel on Educational Technology of the President's Committee of Advisors on Science and Technology, however, I have recently had the privilege of consulting with many of our nation's leading educators, educational technology researchers, and educational software vendors, and have begun to identify certain recurrent themes that have served to complement (and in certain respects, to alter) my own thoughts on this subject.

In the first part of my testimony, I will speculate on some of the advances that might be achievable over the next twenty years in the development and application of various computer-based educational technologies, with special emphasis on grades K through 12. While there is already substantial evidence that such technologies can have a significant positive impact on educational outcomes, my remarks will not be organized as a review of this evidence, but rather as a qualitative discussion of some of the most salient features of these technologies from an educational perspective, and of the potential they may offer for significant advances in educational efficacy over the next twenty years. Because the realization of this potential will depend in part on actions taken within this Congress, I will then briefly consider what will have to be done in order to make such advances possible.

Underlying Technologies

It is extraordinarily difficult to predict with any certainty the exact nature of the hardware that will be available for use in educational applications in the year 2015. Over the course of two decades, both unanticipated breakthroughs and unexpected obstacles will have ample opportunity to render laughable any overly detailed projections one might make today. It seems safe to predict, however, that the computer systems available twenty years from now will be dramatically more powerful than those available today at a comparable cost.

If forced to guess, I might project an increase of as much as a factor of 100 in both computing speed and memory capacity by the year 2015, allowing the power of a contemporary supercomputer to be purchased for less (and perhaps even far less) than a thousand inflation-adjusted dollars in a package smaller than today's laptop computers. Both display and printing technologies are likely to evolve to support significantly higher resolutions and better color quality at a given price, and even inexpensive systems will have the image processing and audio signal processing capabilities necessary to support full-motion video, the realistic rendering of computer-generated moving images (including those produced by computationally-demanding simulation algorithms), and high-quality music and sound processing.

At the low end of the technology spectrum, the processing and memory resources of a computer far more powerful than today's fastest PCs should cost well under a hundred inflation-adjusted dollars by 2015, allowing the embedding of formidable (at least in present-day terms) computational power within telephones, television set-top boxes, and hand-held portable units as well as conventional standalone computers. Such alternative devices would avoid the cost of standard computer display and data entry devices (which are likely to decrease in cost more slowly than integrated circuit components), making at least some forms of computing more widely accessible than is now the case.

The information-carrying capacity of both local and geographically dispersed data communication networks is also likely to increase dramatically over the next twenty years, supporting the inexpensive real-time transmission of (among other things) high-quality audio signals and both still and moving full-size images on a telephone-like, point-to-point basis. A progressively larger portion of the world's population is likely to be interconnected by the year 2015 through the global Internet, which could conceivably become virtually ubiquitous within the United States, depending in part on policy decisions made by state and federal legislators with respect to the provision of affordable connectivity to rural and economically disadvantaged individuals. Among other things, these changes could obviate the need to physically transport such media as records, videotapes, floppy disks and CD-ROMs under many, if not most, circumstances. Electronic mail is likely to become at least as common as fax communication is today, and might well approach the degree of acceptance now enjoyed by the telephone. E-mail, telephone, voicemail, and facsimile communication are likely to be tightly integrated, and powerful workgroup software may be widely used to support collaborative and coordinative activities.

I am personally doubtful that the field of artificial intelligence will have advanced to the point where computers are able to "understand" written English in a fully human-like way by the year 2015. At the same time, I would predict that so-called "weak" methods in natural language processing will by then be used to extract sufficient meaning from text to be of considerable practical utility in a number of education-related applications. In particular, such methods might be used to design powerful, meaning-based (as opposed to solely keyword-based) information retrieval tools suitable for sifting through what will then be a rather massive

repository of textual data available on the Internet, to find material that might be relevant to a given user. Significant progress will probably also be made over the next two decades in computer speech recognition and image understanding, driven in part by the availability of vastly greater computational power and in part by improvements in our ability to represent and manipulate "real world" knowledge. As in the case of natural language processing, however, I am skeptical about the prospects for human-like proficiency in the interpretation of continuous speech (as opposed to isolated words) or complex images by the year 2015.

Individualized Instruction

From the perspective of these hearings, the advances in raw technology that I have just discussed are probably less significant than the ways in which such technology will be used to support powerful new modes of learning for K–12 students within the classroom, the home, and the community. While it would be presumptuous of me to attempt to predict all of the innovative approaches that researchers and educators will doubtless discover over the next twenty years in the course of their efforts to advance the state of the art in educational technology, I believe it is already possible to identify some important ways in which such technology may help to fundamentally alter the nature of the primary and secondary education.

Among the most important potential advantages of educational technology is its ability to individualize the educational process to accommodate the needs, interests, proclivities, and current knowledge and skills of each particular student. Even the earliest drill-and-practice-based computer-aided instruction systems, in which the student was exposed to a successive blocks of instructional text and answered a series of numerical or multiple-choice questions posed by the computer, typically offered the advantages of self-paced instruction. Among other things, self-pacing avoids the need for teachers to target their presentations to some hypothetical "typical" pupil, leaving part of the class behind while other students become bored, restless and inattentive.

Drill-and-practice-based computer-aided instruction systems also frequently support "branched" structures, in which the student's performance on one question determines the sequence of questions to follow. Additional time can then be spent

on material with which the student is having difficulty, while avoiding needless repetition of subject matter he or she has already mastered. Future, more "intelligent" systems may be capable of inferring a more detailed picture of the what the student does and does not yet understand, and of actively helping to "debug" the student's misapprehensions and erroneous conceptual models. If a student is having difficulty learning to subtract, for example, the computer may recognize that he is systematically failing to "carry a one," making it possible to offer specific coaching rather than a simple repetition of the original instructional material.

Another aspect of the computer's potential for individualization of the educational process is the ability to adapt to alternative learning styles. Research has shown, for example, that certain individuals learn most effectively when educational content is presented in visual form, while others make better use of written or verbally presented material. Computer-based learning systems admit the possibility not only of varying the form of presentation to match the student's preferred mode, but of ascertaining which modes actually prove most effective for a given student.

New Modes of Learning

Notwithstanding the attractive features outlined above, many researchers in the field of educational technology now believe that drill-and-practice-based computer-aided instruction systems fail to capture much of the educational potential of contemporary computer and networking technologies. Some of these researchers go so far as to argue that the principal use of computers in schools has thus far has been to automate what amount to minor variations on 19th-century teaching methods, and believe that the truly important uses of technology in education will require a fundamental rethinking of the pedagogical models underlying our traditional approach to the educational enterprise. In my view, available scientific evidence does not justify the offhand dismissal of earlier approaches to computer-aided instruction; many researchers and practitioners in fact suspect that some of these techniques will ultimately prove quite useful under certain circumstances. Any discussion of the long-term impact of technology on education, however, would be incomplete without an examination of some of the emerging themes

within the field of education itself that inform much of what I personally believe to be the most promising ongoing research on educational technology.

I do not purport to have assembled a definitive list of these recurrent themes; indeed, were such a list to be compiled, other witnesses testifying at these hearings would clearly be better qualified to do so. If pressed to identify a few of the most salient characteristics of this emerging paradigm which I have thus far been able to discern, however, I would include the following:

- The student assumes a central role as the active architect of her own knowledge and skills, rather than passively absorbing information proffered by the teacher.
- Basic skills are learned not in isolation, but in the course of undertaking higher-level "real world" tasks whose execution requires the integration of a number of such skills.
- Information resources are made available to be accessed by the student at that point in time when they actually become useful in executing the particular task at hand.
- Fewer topics are covered than is the case within the typical traditional curriculum, but these topics are often explored in greater depth.
- Greater attention is given to the acquisition of higher-order thinking and problem-solving skills, with less emphasis on the assimilation of a large body of isolated facts.

Within this paradigm, the computer is not used to orchestrate the instructional process in a "top-down" manner, but rather serves largely as a *tool* (albeit a uniquely flexible and powerful one) for student-initiated inquiries, explorations, projects, and problem-solving activities. By way of example (and without any attempt at comprehensiveness), this tool might be used as:

- an information retrieval or database search engine capable of extracting information from a single system or from sites distributed across the global Internet
- a tool for the symbolic manipulation or graphical display of mathematical functions, equations, and proofs

- a facility for the examination and analysis of statistical data (which might be used in connection with any of a wide range of experimental or survey applications)
- a general or application-specific numerical spreadsheet
- a vehicle for various forms of interactive exhibits and demonstrations
- a framework for the simulation of any of a wide range of devices and machines, physical systems, human and animal populations, work environments, etc.
- a word processing, document preparation, or outlining system
- a digital workbench for the creation of musical, artistic, and other creative works
- a user-friendly environment for the acquisition of basic programming and system design skills
- a computer-aided engineering workstation supporting the design of mechanical or electrical devices, architectural projects, or even organic molecules
- an interactive hypertext encyclopedia incorporating various forms of multi-media illustrations, and supporting the rapid traversal of cross-reference links
- a medium for communication with other students, both locally and over great distances, and for the organization and coordination of group projects

Much of the spirit of the new paradigm whose general flavor I have attempted to convey here is captured by Plutarch's contention that "the mind is not a vessel to be filled, but a fire to be kindled." Within the educational world of 2015, I would expect the computer to function not as a larger-diameter fire hose, but as a more powerful incendiary device.

8

The Human Element

If computers are destined to play an increasingly important role in education over the next 20 years, it is natural to ask what roles will be played by human beings. Although it seems clear that the expanded use of technology in education will have significant implications for teachers, students, parents, and community members, it is my belief that interpersonal interactions among all these groups will be at least as important to the educational process of 2015 as they are in 1995. Indeed, the changing nature of these interactions is probably as central to the promise of new educational technologies as the hardware, software, and curricular elements I have outlined above.

For better or worse, I see little evidence at present to support the expectation that the advent of new educational technologies will be accompanied by a reduction in the need for human teachers. While this may be a comfort to fearful parents and teachers, it may also be a disappointment to those who have looked to technology for a reduction in our aggregate expenditures on teacher compensation. Although educational *productivity* is likely to rise as technology is effectively integrated into the educational enterprise, this will likely be mediated largely by increased learning (according to some metric) per student hour (and to a lesser extent, by administrative cost reductions), and not by a reduction in aggregate teacher compensation expense per student hour.

The *nature* of the teacher's responsibilities, on the other hand, may be significantly changed by the introduction of technology, particularly when accompanied by the sorts of paradigmatic changes I discussed earlier. When a high school student using the Internet to complete a self-directed project is able to quickly gain greater familiarity with the particular subject area in question than her teacher, for example, the teacher's traditional role as a font of knowledge may become less relevant. Because different students may be conducting different inquiries at any given point in time, however, this traditional role may be supplanted by one in which the teacher spends a considerable amount of time monitoring the activities of individual students (typically by wandering around the classroom and looking at their computer screens) and providing encouragement, direction and assistance as needed. Indeed, recent research suggests that as class size increases, the productivity gains associated with technology-intensive classrooms tend to drop in magni-

tude—an apparent consequence of the teacher's diminished ability to monitor and coach students on a one-on-one or small-group basis.

And what about the students? Will their increasing use of educational technologies deprive them of the opportunity to develop important interpersonal and social skills? The evidence to which I have been exposed suggests that this should probably not be a source of concern. First, it seems unlikely at this point that in the classrooms of 2015, students will spend the most of their time sitting in front of their computers. When one research group provided essentially unlimited computer access to each student in a number of experimental classrooms, for example, it found that students spent an average of approximately 30% of their time at the computer.

Moreover, these researchers noted a significant *increase* in the degree of interpersonal interaction when technology was introduced into the classroom, reporting that the computers typically served as the focal point for extensive collaborative activities, and that students frequently called each other over to show off what they had done and explain how they had done it. Software can also be specifically designed to teach collaborative and cooperative skills, and to support group projects and learning exercises. In short, any fears we might have that the increasing use of computers in education will produce a generation of isolated nerds would seem to be unsupported by currently available evidence.

In considering the human side of educational technology, it is also worth noting that K–12 education takes place within a context that includes not only the student and teacher, but also the parents and other members of the surrounding community. Substantial evidence now exists suggesting that parental and community involvement in the educational process has a significant positive effect on educational outcomes. If at least basic computing resources (perhaps based on television set-top boxes) and Internet connectivity are available within most households by the year 2015, parents should be able to receive school announcements from teachers and administrators, to communicate easily and frequently with teachers, and more generally, to involve themselves more actively in the education of their children. The cultivation of such parental involvement may be particularly important for those students whose economic or environmental circumstances would otherwise place them at increased risk of educational failure.

There is also a growing consensus that technology should be applied in such a way as to foster broader community-wide involvement in the educational process. The linking of primary and secondary schools with research universities, public libraries, and private companies, for example, could make valuable educational resources available to both students and teachers while simultaneously building awareness within each community of the needs of its local schools. "Real-world" projects initiated by outside organizations often generate considerable enthusiasm among students, and frequently prove unusually effective from an educational perspective. Some educators have even discussed the possibility of instituting "tele-apprenticeship" or "tele-mentoring" programs involving brief, but relatively frequent interactions between students and other community members that would be impractical in the absence of networking technologies due to travel time considerations. Conversely, high-tech schools could serve the broader community by making their computing and networking facilities available to local residents outside of school hours, or by offering state-of-the-art job training or lifelong learning programs tailored to community members, thus amortizing infrastructure costs over a larger effective user base while helping to foster intrinsically valuable community integration.

How Do We Get There?

The vision I have sketched of the future of educational technology and its potential impact on K–12 education is by no means a historical inevitability. On the contrary, the realization of this vision will require significant advances in several dimensions. First, the necessary computational and communications infrastructure will have to be made widely available—at least to students and teachers, and ideally, to parents and other community members as well. While it might seem that some technology is better than none at all, attention must be given to questions of equity if we are to avoid becoming a nation of "information haves and have-nots," which could have serious economic and social implications for our country.

Unfortunately, the actual cost of providing computer access to some 50 million American students will be considerably higher than might be immediately appar-

ent. While the price of a basic personal computer system has already dropped to little more than $1,000, studies have shown that hardware expenditures represent only about 25% of the total life-cycle cost of such a computer; the remainder is accounted for by such other expenses as installation, maintenance, training, and systems administration. While the development of novel system architectures and support schemes designed explicitly to minimize these hidden costs could help to mitigate this problem in the future, the operating costs of computer hardware remain a significant obstacle for many schools. Rapid obsolescence is also a significant factor in the economics of educational computing; a large percentage of the computers now installed in our nation's schools, for example, are already so outdated that little educational software is still being written for them. In view of these economic realities, our schools should not regard computer equipment as a non-recurring capital outlay to be financed with a one-time bond issue in the manner of a school building, but as an ongoing expense that must be provided for as a regular part of its operating budget.

The provision of universal Internet connectivity to schools is likewise fraught with non-obvious difficulties. The vast majority of all American schoolrooms are not even wired for telephones, much less local area networks, and some have inadequate electrical wiring as well. To make matters worse, many schools have asbestos within their classroom walls, making an already challenging wiring and cable-routing task even more expensive. Outside of the classroom walls, the principal challenge will be to foster a competitive telecommunications environment—not only within the long distance market, but among alternative local carriers as well—and to adapt federal and state telecommunications policy to make special provisions for affordable Internet access to all schools (and in the long run, to all homes), in both urban centers and remote rural areas.

Overall, about 1.3% of our country's educational expenditures are currently allocated to technology. Recent studies have estimated that this figure will have to increase to between 3% and 5% on an ongoing basis in order to provide the sort of computing and networking infrastructure that will be required to support many of the educational applications I described earlier. While this would still represent a relatively modest percentage of combined federal, state, and local education spending, it is perhaps worth noting that a disproportionate share of this funding

now comes from federal programs whose future will depend on currently pending budgetary decisions.

Although the provision of educational computing and networking infrastructure will present nontrivial challenges, the two areas I believe should currently be of *most* concern to members of Congress are research and evaluation, on the one hand, and professional development for educators, on the other. The magnitude of the first problem is illustrated by a (somewhat oversimplified) comparison between the American education system and the American pharmaceutical industry. This year, the United States will spend about $70 billion on prescription and non-prescription medications, and will invest about 23% of this amount to develop and test new drugs. By way of contrast, our nation spent about $285 billion on K–12 education in 1993, but invested only a fraction of 1% of that amount to determine what educational techniques actually work, and to find ways to improve them. Of the Department of Education's total budget of about $30 billion, a relatively insignificant portion—on the order of $50 *million*—has thus far been allocated to educational research.

To continue this comparison along a different dimension, although some hundreds of thousands of Americans have been enrolled in FDA-approved trials designed to gather data on the safety and efficacy of new drugs, we have never undertaken an even remotely comparable effort to systematically collect the sort of data that might help us to evaluate the effectiveness of the educational techniques we are currently using to teach America's 51 million K–12 students. With suitable ethical controls (which might, in fact, be modeled after those employed in FDA trials) to insure that students are never subjected to experimental approaches believed to be inferior to current best practice, a wealth of scientific data could be collected on the efficacy of alternative educational technologies by conducting trials within a relatively large, reasonably representative set of actual classrooms throughout the country. Even a small fraction of our country's student population would be sufficient to conduct numerous experiments with sufficient statistical power to tease out all but the smallest effects. By failing to conduct such experiments, we are in effect wasting an immensely valuable source of data, and foregoing an irreplaceable opportunity to improve our educational system materially over time.

It should be emphasized that, from an educational viewpoint, the greatest need is for research not on the underlying technologies, but on alternative approaches to the educational process itself, and on the manner in which various technologies might most effectively be used to support these approaches. In order to maximize the likelihood of discovering intellectually divergent, but highly effective approaches within the limitations imposed by current budgetary constraints, support should be provided at a relatively limited funding level for a substantial number of independent, investigator-initiated, early-stage research projects based on a wide range of alternative approaches. Ultimately, however, larger-scale funding will become necessary for rigorously controlled randomized prospective trials, involving a substantial population of students, on the actual effects on educational outcomes of different approaches to the utilization of specific educational technologies.

One rather complex (and currently rather contentious) issue that is central to the design of such experiments relates to the manner in which "favorable" educational outcomes should be defined and measured for purposes of evaluating the efficacy of alternative approaches to the use of technology in education. Conventional standardized tests offer the advantages of widespread availability, straightforward administration and scoring, and familiarity to and credibility with the public at large. Such tests, however, tend to place more emphasis on the accumulation of factual knowledge, and less on the acquisition of higher-order thinking and problem-solving skills, than would be desirable for the measurement of those forms of educational attainment that many members of the educational community have come to regard as most important.

Since both researchers and teachers can be expected to develop pedagogical techniques that optimize performance with respect to whatever criteria are employed to measure educational success, optimal progress within the field of educational technology will depend critically on the development of metrics whose validity and reliability are generally accepted by researchers, educators, parents, and legislators. Unfortunately, no firm consensus has yet emerged on the best choice of such a metric. For the present, the best approach may involve funding further research in the area of evaluation, but without waiting for the results of this research before initiating serious efforts to evaluate (using one or more currently available metrics) alternative approaches to the use of educational technologies.

While the development of underlying technologies is likely to be driven largely from within the private sector, there are both theoretical and empirical reasons to believe that only the federal government can be expected to provide an appropriate level of funding for research and evaluation in the field of educational technology. This situation arises from a particular form of economic externality related to the lack of appropriability of certain forms of intellectual property. Suppose, for example, that a particular private company, which I will refer to as Company A, were to expend significant resources on research aimed at the discovery of powerful new techniques for the application of technology to education. While Company A might well find it possible to commercially exploit any successful results that might be discovered in the course of its research—through the sale of a proprietary software product to schools, for example—it would generally not be able to prevent other companies from analyzing this product and using the benefits of this analysis to design a competing product, thus appropriating for itself a portion of the returns accruing from the results of Company A's research, and reducing Company A's profitability.

Anticipating its inability to capture the full benefit of its investment in research, Company A (and all of its competitors, since each would be faced with the same problem) may be expected to systematically invest less (and in many realistic cases, dramatically less) on research and development than would be optimal from the economic viewpoint of the Company A and its competitors in the aggregate, and from the viewpoint of students, schools, and society as a whole. Such "free-rider" problems are classically resolved through the use of pooled funding at the highest possible level of taxing authority—in this case, through investment at the federal level. (State or local funding would result in another free-rider problem, with each state or locality having an incentive to systematically underinvest in research funding in order to "ride in the tailwind" of the others.)

The other area I believe merits special attention from those responsible for formulating educational policy is professional development for teachers, school administrators, curriculum planners, school librarians, media specialists, technical support staff, and the faculty of schools of education. In the case of educators, I believe that expertise related to the underlying technologies (sometimes referred to under the banner of "computer literacy") is not nearly so important in this regard as an

understanding of the manner in which these technologies can be applied the process of education. In this regard, it might be worth noting that some 50% of all teachers are now estimated to have computers in their own homes. A much smaller number, however, have access to the information and educational materials that would be required to make optimal use of similar technologies within their respective schools. In addition to pre-service and in-service professional education programs dealing with the ways in which various technologies might be utilized within the classroom, it is important that teachers be provided with access (which might ultimately be provided through the Internet) to a wide range of educational materials (including software packages developed by other educators), case studies, lesson plans, and sample projects, and with ample opportunities (some of which might again by provided on an online basis) for ongoing discussion with other members of the educational community.

Conclusion

America's offices and factories have been transformed in recent years by the use of new technologies. But the workplace of our children is the classroom, and most of our nation's classrooms do not even have telephones. If we are serious about preparing our children for 21st-century jobs, we should not expect this process to take place within 19th-century schools. New technologies offer the potential for dramatic improvements in educational outcomes over the next twenty years, but much of this potential is likely to remain unrealized in the absence of at least modestly increased federal investments, particularly in the areas of research, evaluation, and professional development. While such investments may be expected to earn unusually high economic and social returns relative to most alternative expenditures, both microeconomic theory and historical precedent suggest that neither the private sector nor state or local governments will have the appropriate incentives to invest at an economically optimal level.

While mindful of the difficult budget choices with which this Congress is currently faced, I am grateful for the opportunity to alert the members of the Committee on Science and the Committee on Economic and Educational Opportunities to the very real dangers—not only to our children's intellectual well-being, but also to

their long-term economic security—that might be posed by an effort, however well-intentioned, to economize on these particularly important investments.

Chairman WALKER. Thank you very much. We appreciate all of your testimony.

What we want to do is go to questions of members. We're going to enforce a five-minute rule. We have lots of members here and lots of people on panels, so I'm going to try to have us live within a five-minute rule for questioning.

Let me begin with just a couple of questions here.

Professor Papert, you said something to the effect that in the future, that there's going to be a place where children learn but it won't look like today's classroom.

Would you give us an idea what you think it will look like?

Professor PAPERT. Maybe it'll look like a research lab. Maybe it'll look like an active, creative architect's office. I think it'll look like a place where people are engaged, young people of mixed ages. It was absurd that we should deprive eight-year-olds of contact with anyone except people at their own level of incompetence.

[Laughter.]

Professor PAPERT. Where people of mixed ages will be engaged in projects that are rich in knowledge and using the technology to research, get knowledge that they need in order to conduct long-term projects.

Chairman WALKER. Doesn't that begin to look a little like the old one-room school?

Professor PAPERT. I think the one-room school's a better model than the big, massive high school building, yes.

Chairman WALKER. That's interesting.

And would you agree with the point that Dr. Shaw made, that the teacher in that kind of setting becomes a kind of coach, an information manager type of individual, rather than somebody who is imparting information as their primary function?

Professor PAPERT. I agree with those words, but I'm afraid Mr. Shaw doesn't get it. I think his phrase that the teacher, quote, will be a coach walking around the classroom, seeing what the students are doing, is a typical translation of a new concept into the old framework.

There won't be a classroom, the teacher won't be walking around seeing what the kids are doing, the teacher might be part of this constructive project.

Dr. SHAW. To be fair, most researchers now to whom I've spoken do not agree with Professor Papert on this point.

Professor PAPERT. I did preface my remarks, I think there's an education establishment that has its head wedged in a culture that grew up over a century during which there was the most lethargic progress in education of all fields of human activity, and they continue to suffer from being part of that culture.

I think Congress ought to find some ways of planting seeds where there can be real radical change, real radical experiments, which are not subject to the consensus of the researchers and other members of the education establishment.

In my written testimony, I suggest that you could use the Job Corps, for example, that belongs to the federal government, as a place where real innovation could be made without many of the difficulties that attend trying to introduce it into the classrooms. It wouldn't even cost anything. All you'd have to do is to free the bid-

ders for Job Corps Centers from the micromanagement of a sclerotic bureaucracy, and let people who want to innovate there, innovate.

Chairman WALKER. I promised you a lively discussion.

[Laughter.]

Chairman WALKER. Let me go to the point that Dr. Shaw raised in terms of the specific terminology, but I think I heard it throughout all of your testimony, and I just want to make certain I did.

Do I hear each of you saying in some form that what technology promises to be able to give us is the ability to individualize instructional programs, and that it will be based then on the students' talents, the students' abilities, the students' intelligence, what the student brings?

And I assume that this would be in consultation with parents and so on as that instructional program be designed?

Professor PAPERT. No, no, no. We've got to give up the idea that learning is instruction. Instruction is a small part of learning. The important part of learning is doing. And I think the big change is that we will move from an emphasis in instructionist thinking to constructionist thinking.

Chairman WALKER. Is there an individualized curriculum?

Professor PAPERT. I think there'll be individualized activities which will be of such a nature that each individual will be able to draw on personal—

Chairman WALKER. And each student will not be learning the same thing as every other student?

Professor PAPERT. Absolutely, that's right.

Chairman WALKER. Okay, so it's individualized.

Dr. Kay, would you agree that that's a—

Dr. KAY. Yes. I think if you look at six-year-olds, they are the greatest mathematicians they'll probably ever be in their life. They're the greatest scientists they'll probably ever be in their life. They're really great in general.

And if math and science and so forth were easy, we could just let them invent it, but we know that it took thousands and thousands of years to actually make real progress there.

So the balance I think is that the students are inventive and creative, and when an adult is involved, what an adult can do is to have some sense of where things might be going. So the adults have some sense that the math might wind up in calculus some years down the road, and that could have something to do with the kinds of things that the kids are encouraged to look at.

But the kids have to invent it for themselves and the computer there can be a tremendous factor.

I think nobody has been able to show yet a computer curriculum of any kind, all by itself, that when coupled with children, will have the same effects as children in an atmosphere where adults really understand them and understand how to set up an environment in which all of their energies can be directed at learning, but where the outcomes are likely to be fruitful.

Chairman WALKER. I'm going to try to stick by my own rules, and the buzzer has sounded for my time.

So I'm going to go to Mr. Goodling.

Chairman GOODLING. One comment and one question.

Like Chairman Walker indicated, an awful lot did sound like the one-room school that I attended where Miss Yost planted the seed, and then she wandered around the room to see what we were doing to cultivate it.

There were all ages together, and a teacher today of course, a good teacher could have them all the same age in the classroom, but the good teacher will have them at six, eight different levels, whether they're at a reading level in first grade or fifth grade and they're still in first grade, it is still the same idea, but not a difference in age.

But it does sound like the one-room school.

But my question is, everything I've seen in education, we come along with new ideas and innovative technologies and so on, we generally institute them, and then we talk about training and preparing the teachers for the job.

I haven't seen anything change, and perhaps Professor Papert and Professor Dede could respond, maybe all of you could respond. Is anything changing in teacher education?

I haven't seen anything and I'm just wondering if we make all the changes, is there anything going to happen as far as preparing the teacher or the observer or whatever we're going to call the person in the future to handle the situation, beyond all the other responsibilities they've had put upon them?

Professor DEDE. There are some changes taking place in teacher education, not as rapid as they need to be. And some of the answer for that is that the faculty of schools of education need to catch up to the 20th century.

And some of the answer for that is our mechanisms of accreditation and what parents and communities expect of teachers often force teachers back into older models of teaching.

In a sense, we say, yes, we want a teacher that's innovative but I also kind of want a teacher that was like the one that I learned so much from, that helped me to be successful in life.

And I think that until we evolve in the minds of parents and taxpayers and community members, a broader sense of what it means to do teaching and learning and a shared responsibility for that, so that it's not a matter of drycleaning, where you drop off a student on the step in the morning, and they come back brainwashed in the afternoon.

When we get to a different and a more powerful model of that, then I think we'll see the pressures for changes in teacher education increase

Dr. KAY. One of the things I mentioned was the piano as a metaphor, but I could also say, 150 years ago, the response was let's put books in every classroom, and they are in every classroom, but in fact most teaching is done from textbooks and is in accord with textbooks.

Books are all about diversity of opinion, and about learning at your own rate, and about learning as deeply as you want. They're all about individualized learning. But textbooks are about lock-step learning.

So this is a perfect example of a great educational technology starting some 400 and 500 years ago, that has actually been coopted into much more of a party line from what it could be.

And I believe that's exactly what's going to happen to computers, is what's happening to computers in classrooms right now.

Professor PAPERT. I think as far as the schools of education go, they're as sclerotic as the rest of the system, and are not doing anything significant.

However, I think that there are wonderful people in the profession of teachers, and I've seen some incredibly good learning conducted by individual teachers on their own time with their own effort, and that's where I see the seed of real change.

And some of the most interesting actions are the creation by teachers, who are allowed in some school districts, to start alternative schools where they can really pursue their own, a group of like-minded teachers can pursue a different philosophy of education and really carry it out.

I think some of the wonderful things are happening in those areas.

And one thing that could be done at a national level would be to foster that sort of allowing the teacher who puts the energy in to learn something new to be able to carry that into practice.

Too often, sadly, I've had teachers really work incredibly hard for a whole summer in a workshop that we've run, and then go back to find that their excitement and they're going to carry this out in the classrooms is frustrated by the system into which they have to go back. That's one of the most heartbreaking things I've seen.

And I think if you can find a way to get around that by empowering those teachers, you will really plant some real seeds.

Chairman GOODLING. I was going to suggest that unfortunately, often times the creative or innovative teacher is restricted. And just one quick example. Supervising student teachers in Pittsburgh when the so-called missile crisis was happening in Cuba, the headlines in the Pittsburgh paper said missiles could hit Pittsburgh. And I couldn't wait to get there to see all my student teachers talking about this possibility and for the first time turning these kids on.

Not one mentioned the headlines during the entire day. And that night, when I took them to task, they said, oh, we were told that we must stick strictly to the curriculum. We can't deviate.

Chairman WALKER. Mr. Brown.

Mr. BROWN. Gentlemen, in the 1960s, there was a great upsurge of interest in radical ways of education and much of it I'm sure you are familiar with. Classrooms without walls, getting involved in the community, that sort of thing.

I had the pleasure of being associated with a radical teacher by the name of Ivan Illich who, 25 years ago, invited me to participate in a school he was conducting in Mexico where he had originally started out training Catholic priests for the service in Latin America, and he decided, and part of the decision cost him his priesthood, that they had too many priests in Latin America and they didn't need to send more down there. And he changed his school into one that taught not only language, but how to reform society.

And this strikes me as being somewhat close to the message that may be coming from you, that it's not the technology so much but how we can change the society and involve the students as a part of that society.

I'd just ask you to comment on that and see if I'm anywhere close to being right?

Professor PAPERT. Yes. Well, I think it's both sides of that.

The technocentric people who think that technology will solve it are totally wrong.

But a little parable for the other side. Leonardo da Vinci invented the helicopter but there was no way in which you could actually make one because you would have needed a whole lot of other infrastructure; materials, science and all sorts of stuff that wasn't there.

I think that there've been generations of really deep thinkers about education including Illich, including my own Professor Piaget, who really saw dead on. They knew what to do but there wasn't the infrastructure to be able to carry it out on a mass scale.

So the ideas were there, the technology wasn't. Now we've got the technology and too often it's divorced from the ideas.

I think we can put these together.

In my last book, "The Children's Machine," I spelled this out somewhat that in a sense, the technology gives us today the infrastructure to put into practice ideas like learning by doing, learning by experience, coaching. All these are old ideas, but I think that for the same reason that da Vinci simply couldn't have made a helicopter, however smart he was, these people could not put into practice.

Our own American John Dewey, almost 100 years ago, said almost everything about education that we can say today, but it couldn't take effect because we didn't have the technological infrastructure.

Professor DEDE. And if I could build on that. I think one vital difference from the sixties is that the parents and citizens see their workplace changing dramatically in a way that wasn't true then. And as a result, there's a growing consensus that the kinds of skills that are important in today's workplace are also important in today's classrooms.

Dr. KAY. Just one small sentence. Many of the writers of the Constitution thought that a new constitution should be written every 20 or 30 years by each generation. This is Jefferson's view. It was also the view of Tom Paine.

That's a little radical, I think. But a slightly less radical way of thinking about it is, what they really wanted was each generation of Americans to reinvest themselves in their democracy by thinking that they had a strong part of reframing it.

So I don't think—that's even a radical idea today, but I think it's actually very much in tune with what America has been about.

Mr. BROWN. That's what the Republicans are trying to do today.

Dr. KAY. Is that right?

[Laughter.]

Dr. KAY. I'll have to study closer.

Mr. BROWN. Illich's book was called "Deschooling Society," and basically he took the whole system apart, not just the classroom, but the whole system.

Do you have any comments, Dr. Shaw?

Dr. SHAW. Yes. One minor one.

I think that connections between the classroom, and education in general, and the rest of society is actually quite important to the educational process.

One of the things that we actually have some evidence about now is that students who are involved in real world projects, and especially projects in which people in the outside world are depending on them for something, tend to be highly motivated. They tend to learn tremendous amounts, sometimes about only the very specific things they're working on, but they learn higher-order thinking skills that are extremely important.

And one thing that I think that this means is that we have to have involvement in the educational process not just on the part of educators and education schools.

And if I can just use this as an excuse to interject this, I have to disagree very strenuously with what Seymour said about the education schools, that there's nothing interesting going on there. It's just an appalling remark.

These are people who've given their lives, some very smart people, to studying some of these problems, and my Ph.D. advisor always said, whenever you see a body of people, even if you disagree with what they're doing, who are very smart and who are writing a lot of things, usually there's something there and you should try and understand what it is.

I suspect that part of the problem is that it doesn't agree with Seymour's own particular model.

But the fact is I think we have to involve them. We also have to involve companies and that's a key thing.

While I've said that the federal government must do a lot, the fact is that the companies in our society now are going to have to pick up a big part of the burden. That's one of the reasons that the President just had a meeting two days ago with the CEOs of a number of the top American companies.

George Lucas was there, Michael Eisner, Gerald Levine, Ted Turner, and the President, the Vice President, the Secretaries of Education and Commerce. The representation of Ron Brown there was an interesting one because it ties in education to society in two directions.

One is to help education. The other direction, though, is that this administration is committed to education partly because if we're really going to have students who evolve to be able to hold 21st century jobs, high-wage, high-skill jobs in the next century, it's not going to happen if they don't acquire those skills.

So I think that there are a lot of reasons for having some very close ties between industry, educators, and the students themselves and their parents.

Mr. BROWN. Thank you.

It's a sign of my age, but I tend to think of previous explorations of this topic. And I'm reminded that Buckminster Fuller delivered a long lecture, translated into a book later called "Education Automation," which in my opinion was exactly the wrong way to go about changing education, but it was his effort to show how modern technology would affect education.

And I'm sure this was 30 years ago that he delivered this lecture at Southern Illinois University.

Chairman WALKER. Mr. Clay?

Mr. CLAY. Thank you.

Some of your technological proposals are quite revolutionary, but I guess the most radical idea that I'm hearing from each of you today is that there's still a role for the federal government in education.

Let me ask you, Professor Dede, when we talk about the future of education here, are they doing the same thing in Europe and Japan. And if so, can you tell us some of their relative weaknesses and strengths?

Professor DEDE. I think that all countries across the world are still somewhat mired in the idea that mastery of facts is somehow the fundamental goal of education.

And if we look across the world at different systems, there is a disproportionate emphasis on standardized tests as the true metric for determining whether or not students are coming out prepared to succeed in life.

And unfortunately, there's a lot of research that shows that those are a relatively poor indicator of how well people actually do ten years later as parents, as citizens, as workers.

What we are starting to see in Europe and Japan and countries across the world is a shift from the just-like-me curriculum where professors and teachers try to create students who are really brought up just the way that they were, to sort of a just-in-time learning while doing curriculum that relies on more sophisticated measures, similar to those that David Shaw was talking about in terms of authentic experiences with problem-solving, and then people from different roles judging how well students are doing in terms of that kind of problem solving.

What we're beginning to see across the world is moving away from teaching what we know and how we know it to what to do when you don't know, and how you solve problems when you don't have all the facts at your disposal immediately.

And as you know from your own experiences, we live in a world that's like that now. By the time we understand a situation, it's already changed before it's possible to act in full understanding of what's going on.

So I think that there are ideas out of Europe and Japan that are valuable. But we have, in many ways, a unique culture and a unique economic niche in the world, and our challenge is to evolve a truly American response that relies on the fact that our schools are local, rather than driven by a national educational system.

Mr. CLAY. Dr. Shaw, you were talking about 15 years or so from now about the cost of making sure we can reduce the cost of this technology.

How cost effective is it now? Is there any idea what this would cost us if we implemented some of these ideas?

Dr. SHAW. Yes. The answer to that question is a complicated one. First of all, in terms of cost-effectiveness, there is some data, but much of it is with older styles of pedagogical models, older styles of the use of educational technology.

To answer that straightforwardly, we know that if what you want to do is teach a bunch of basic skills in isolation, you can do it faster and less expensively this way.

I don't think that's actually what we want to do.

In terms of what's likely to happen in the future, I think the best prediction, if we handle things correctly, would be that we're not going to significantly reduce the overall cost of education directly through the kinds of important things we're talking about.

What we're going to be able to do is educate much better, and give people much better ability to, as Professor Dede was saying, to solve the real problems they'll face later on in life when they don't know all of the answers.

On the other hand, there are some things that technology is going to do pretty much automatically in terms of productivity. If we can get a handle on the organization within schools, some administrative costs are going to be reduced.

There are certain areas where I think that that will have an effect. But I think we have to be prepared for the fact that historically, major changes in paradigm, even when they save a lot of money in the long run, in the short term actually result in a decrease in productivity.

We're going to have to be prepared to spend some money to make that transition.

So in the long run, I think that we're going to see a great deal of cost-effectiveness, especially if you're interested in the outcomes and not just the total cost. But in the short term, I think it's misleading to have the simple productivity model where we'll bring in computers, we'll automate a process in some way, and everything will become less expensive.

But in some sense, we have no alternative. If the alternative really is that we train people to be competitive with textile workers in developing countries, then in the long run, that's not cost-effective either.

And if we look at this on an investment basis, as opposed to an expenditure basis, even just looking at tax revenues alone, we should be able to get extraordinarily high rates of return from every dollar we spend at the federal level, because it's the highest level of taxing authority and it deals with the problem of economic externalities.

That's the right level to do it, and we would expect to get many dollars back in the long run, not just through savings in education, but through increased productivity, through basically positioning ourselves in a way such that our country can be economically competitive and can retain the standard of living that we've all become accustomed to.

This isn't strictly an economic problem. You know, we have to be prepared for the fact that if we don't educate, up until now, even though everybody talks about increased foreign trade, the fact is, most of what happens, happens just here locally in the country.

That's going to change. We are going to have a truly international economy. Trade barriers are going to be lower, and I think that's a good thing over time. But it also means that if we don't have the skills to compete for the kinds of jobs that are going to be at the top end, rather than the bottom end of the pile, that we're going to have to be comfortable having the same sort of standard of living, at least for a large part of our population, that is characteristic of many less-developed countries.

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And we don't have any experience, as a democracy, living in a society where perhaps 75 or 80 percent of the people earn what might be the equivalent of 30 or 40 or 50 cents an hour. That has never happened here. And it raises some important social and political issues.

So we really have to look at costs in a very broad context. When my daughter, who will be born in eleven days if all goes well, is 20 years old, we have no guarantee that she'll be in the environment that we're in now.

And the decisions you're making here about what our educational system will actually look like are going to make a huge difference in that.

Mr. CLAY. Thank you.

Chairman WALKER. Mr. Fawell?

Mr. FAWELL. The picture that I'm getting from you folks, and there seems to be a difference insofar as Dr. Papert is concerned and the rest of you, is, if I construe what you're saying correctly, I think there was testimony that 20 percent of the problem is technology, but I should say 80 percent is what to do with that technology and the effective use of it, etcetera.

And Dr. Papert, is that the correct pronunciation?

Professor PAPERT. Papert.

Mr. FAWELL. Papert. You seem to be saying that insofar as having the technology in the classroom, it won't be like that piano that I think Dr. Shaw referred to where the kids might learn chopsticks, but perhaps not go too far beyond that.

You seem to be saying, you know, stand back, get out of the way, we don't need standards, we don't need curriculum, let the ideas and the technology spontaneously come together, and you're going to have some really creative education taking place.

And I have, I would like to believe that. I have trouble seeing it taking place. We haven't used much of the technology that has come forth so far in the classroom. It's been very difficult to do that even.

But I'm not quite, I don't, what we really have to find out, it seems to me, is how, how do we get that technology, first of all, into the classroom. Is it cost, etcetera.

And then what do we do about enabling children, especially in the inner city, let us say, and rural areas, etcetera, in a position, first of all, to be able to begin handle that technology in order to be able to have the access to all that the informational systems will give to us.

Can you clarify my thinking a bit on that?

Professor PAPERT. Yes, I can.

First of all, I did not mean to say that simply putting the technology there would result in any spontaneously or automatically producing good changes. Certainly not.

I don't think the problem is getting the technology there, certainly not in economic terms.

In my written testimony, I do some arithmetic that shows that giving every child in the country a computer would raise the cost of education only by two or three percent, and that I don't think anybody questions that it would produce more than two or three percent in increased benefits.

Mr. FAWELL. I found that to be very interesting.

Professor PAPERT. It only appears to be expensive to schools because accountants have played tricks and technology, computers are on the same budget as pencils and so they appear to be enormously expensive. But if you consider that many school districts, the one where I—in Cambridge is exceptional maybe, but they're spending $10,000 a year per child, and even in poor districts, they're spending $6,000 or $7,000 per year per child. And you could buy a computer with a life time of five years would be for $1,000 or $500, if we really pushed the industry to do it, and that's $100 a year, and it's a negligible—

And I know Mr. Shaw is getting angry with me.

Dr. SHAW. No, no, I'm not angry, but this is just not correct. Actually 75 to 80 percent of the cost, the life cycle cost of a education isn't the hardware, so that analysis—

Professor PAPERT. But is the what?

Dr. SHAW. It's maintenance. I agree with your point, I just don't believe in unrealistic—

Professor PAPERT. I'm sorry, but it's exactly the problem is that you're thinking in terms of injecting the technology into the school system as it is.

We have done experiments actually starting in colonial, in third world countries, where there wasn't anybody you could pay to maintain them.

The kids can learn to maintain the computers. If we only changed what they learned so that they could maintain those computers, that would not be part of the cost.

And the fact that you quote that, and it's quoted all over the place, shows how people are interpreting the new ideas in terms of an old framework, and so come to misleading conclusions.

And that's my whole thesis that I'm trying to push here, that you need systemic thinking. You need to understand that all these questions such as how the thing gets maintained, what the kids learn, how the school is structured, all these have to be taken together as a whole.

So I mean, I think the kids could possibly even make the computers or assemble them. There are all sorts of ways—

Dr. SHAW. I don't think that's a very good idea, Seymour.

Professor PAPERT. We could really change—but it needs to be explored, and if you look in the literature——

Dr. SHAW. No, it actually doesn't. That's not a very good idea.

Now I agree with your main point, and I think we have to look at systemic changes, but representing to Congress that for $100 a year, we can put computers in the school is not doing them service.

I actually think it's a very good idea, the idea of getting students involved in maintaining the computers and doing systems administration, actually not in the low level manual labor, but in many of those tasks, and I think it's a good idea not largely for economic reasons, but because there's considerable evidence that that's actually a valuable educational experience.

But we're kidding ourselves if we think that—one of the problems actually in the real world right now is that states are evaluating the purchase of computers as if they were capital expenditures,

the same way they do when they buy a building and they issue a bond issue, and they project a useful life.

The useful life of a computer, first of all, isn't 5 years right now, it's 18 months in industry. Thus, projections are it would be 2 to 3 years in the schools.

And we can probably involve the students in some aspects——

Professor PAPERT. Sorry. I know schools——

Chairman GOODLING. Mr. Chairman, they're sounding like members of Congress.

[Laughter.]

Mr. FAWELL. Will the record show that Dr. Papert figuratively was pulling hairs out of his head.

[Laughter.]

Chairman WALKER. Perhaps we can continue the debate with the next questioner, Mr. Sawyer.

Mr. SAWYER. Thank you, Mr. Chairman.

It was a wonderful debate, and I don't really want to change the subject because it was going so well.

[Laughter.]

Mr. SAWYER. But I am interested in a topic that Mr. Goodling touched on, and that our answers touched on, but that didn't really get much beyond that point. That's the question of what we mean by who we assign whatever the equivalent role of teacher is.

We talked about teacher credentialing, and teacher preparation, but it seems to me that if we're looking at that role, it is a role that is changing in itself. We're continuing to talk about credentials which, issued at the beginning of career, are sufficient for a 30-year duration, at a time when change is a fundamental characteristic of the age that we're in.

And where we're really not talking about applying the same kind of seminal thinking to the development of those skills that we bring to whatever is the equivalent of classroom that we are to the application of the technology in learning itself.

And so what I really want to ask you about is what we seek to prepare teachers to do and how we make that preparation a more continuous process throughout a career. The whole business of the kind of model that we use—is it a socratic model? Is it a matter of posing questions and framing problems?

What becomes the purpose for which we are preparing people to function as teachers?

Professor DEDE. As somebody who works in a teacher preparation institution, let me try to answer that question.

Historically, some of what we've done with teachers, as we said, you need to know your subject, and you need to know something about instruction, and much of what you're hearing from the panel is that yes, it's important to know something about your subject, but the subjects now are blurring across a whole range of things that apply to authentic problems, and that knowing something about instruction is perhaps less important than knowing something about learning and being able to think like a learner and being able to facilitate learning.

In business, often what we see now in effective organizations is a community of knowledge in which employees don't know everything that they need to when some novel problem comes along, but they work as a team, they reach outside of the organization. The really effective employees, the workers and the managers, are good at learning how to learn and organizing people to work in teams.

And I think that some of that is the new role of the teacher.

But what's different between the workplace and the classroom or the learning setting is that the children are not adults, and that often the teacher has to be able to think like a child as well, and to recognize developmental stages and to recognize how to phrase something in a way that's appropriate for the child, rather than appropriate for a peer.

So I would characterize the kind of shift that's taking place in teaching as partly the spreading out of subject matter to not narrowly specialize. Partly understanding how to organize and create a community of knowledge that may reach outside of the classroom, and partly understanding learning in a deep way as it's appropriate developmentally for the students that you're working with.

Dr. KAY. I'd like to disagree in a fundamental way, first with your supposition. I went to school 50 years ago, went to first grade 50 years ago, and I think somewhere around second grade, I realized that my teachers actually didn't know very much about mathematics.

I was getting interested in it. My father was a scientist. And at some point, I realized, gee, my teacher doesn't actually know. I know more than my teacher does right now. And the problem was that the teachers didn't know that they didn't know.

Will Rogers said the problem is not what we think we don't know but what we think we do know.

And science has made its way by being very careful about what it doesn't know, and very, very careful about what it thinks it knows.

And I think that the real change in teachers that should happen is that teachers shouldn't think that they know their subjects because nobody can, and it hasn't been true for hundreds of years.

The biggest problem is that teachers knowing a little bit think they actually know enough to teach it.

Mr. SAWYER. That's precisely the point behind asking the question in terms of giving a credential at the beginning of the year, and—

Dr. KAY. Yes. And what I'm saying is that it's always been true I think, or at least it was true 50 years ago. And so the critical thing for teachers is not so much to be trained in their subjects, but to be trained in what they don't know, is to have a good sense—for instance, every scientist that I know of is pretty darn humble about what they think they know in their own field, because they've learned enough to realize their ignorance is abysmal and in fact our ability to characterize the world is not nearly the way it's portrayed on television.

And so what you need is an opposite kind of person. You need a person who is constantly saying, well, I don't know, but let's see how this turns out, rather than a person that says, well, I do know, and this is the party line.

I think that is the critical change. And once a person takes that attitude, then they're actually much better at their subject than they ever were before, simply because they're open to touching more areas of it.

Professor PAPERT. I've said the same theme, and it's a nice phrase, I think. Schools are really bad places for children to learn because they are bad places for teachers to learn.

And if we can change the school into a place where what they're dealing with isn't the multiplication tables but exciting subject matter, the teachers would be learning, as well as the students, in the same process. And that's the only answer.

And if there's any credential we would like teachers to have, it's to be good learners.

And I think the trouble is, you can take a lot of courses about how to be a good teacher, instructional theory and the pedagogy. We don't even have a word in English for the art of being a good learner, as we have, you know, what is to learning as pedagogy or instructional science is to teaching.

I think if teachers were, if they're going to be credited for anything, it's for being good learners so that they can participate in the learning process, model the learning process, set the example.

I don't think they need to know about learning. They need to be good at it.

Chairman GOODLING. I think the observation goes back to teacher training again. The elementary teacher expected to teach all subjects, very little if any math in high school, and no math in college, and all of a sudden they're out there.

But at any rate, Mr. Roemer?

Mr. ROEMER. Do you want to go back to your—

Chairman GOODLING. No, you're next.

[Laughter.]

Mr. ROEMER. Thank you, Mr. Chairman.

We'll try to get back to that healthy debate that was one of the most entertaining parts of this whole hearing between Dr. Papert and Dr. Shaw.

Dr. SHAW. I hate to say it, but I agreed with that last point.

[Laughter.]

Mr. ROEMER. You haven't said anything for awhile. We'll try to get you back into the debate here.

Let me say, first of all, in prefacing my remarks, that I believe that we don't need to tinker with the schools either. That we need some basic transformation in our schools.

We have many problems there. Technology certainly is not going to be the panacea for all our problems.

Let me, as Dr. Papert did, tell two parables, and one of them will be a question, and then get into the other one.

The first one is bragging about my son a little bit. I have a two-year-old that can get onto the computer, can turn it on, turn on the software and get into the CD ROM of Playschool. He loves it. It helps him count and play games and learn so much. It's incredible technology.

To what degree are we putting so much emphasis on even these two-year-olds and twelve-year-olds being entertained and having this learning academic technology.

To what degree are we overestimating it?

And let me say that when we said that we thought television would be such a great tool in our schools and Channel 1 and all these things were going to be the latest innovation to help us transform teaching and learning, it has not transpired.

Now certainly as Dr. Papert or Dr. Kay might say, we need to transform the infrastructure out there, not just the school and teacher.

How can we get this technology, whether it be Broder-Bond or Edmark, whether it be different computers, whether it be the hardware or the software, to go the route to help us achieve this dream that we're talking about this morning, and not go the route that so much commercial television has, where they categorize the Jetsons and the Flintstones as educational television.

I think on tv, PBS and maybe Nickelodeon are the only tv stations that are doing much to challenge our children.

Dr. Shaw, where do we go to make sure that the private sector and the commercial end of this fulfills this dream that we're seeing?

Dr. SHAW. Well, I've asked exactly that question over the last month or so of at least half of the CEOs of the large educational software companies in our briefings. And the answers differed in some respects, but there were a few things that were brought up that were in common.

First of all, just to understand the basic situation, the reason that the vast majority of the software development effort has gone toward the home market, as opposed to the school market, has been in part that it's very difficult to sell to the, for various reasons, very difficult to sell to the school markets, and much easier to sell to the home markets.

One problem is fragmentation. Right now, many different states and different regions have different standards for adopting software, some of them very stringent.

For the home market, you just produce a product and if you advertise it and it's a good product and it gets good reviews and so forth, people buy it.

It's much more complicated within the school systems.

The exact solution I'm not sure of, but that is one of the problems that they face.

Another one of the issues that they're facing now is just the availability of hardware. About 40 percent of all of the machines in the schools right now are Apple 2Es, I believe, I know early Apple machines, for which essentially no software is still being written, because it's too expensive to write for many platforms.

This is not a criticism of Apple, which is doing wonderful things in education, it's a reflection of some of the economic problems involved in getting modern computer equipment into the school and maintaining them.

Many of the computers that we do have, even contemporary ones in the schools, are not being used, partly because of teachers not understanding them, but partly because they don't have the resources to keep them maintained.

And in fact one of the things the President just announced was something called the Tech Corps, which is going to be focusing on

having private sector volunteers provide assistance to the schools to solve some of those problems.

It remains to be seen how much of the problem that solves, but at least it's one issue that where I think bipartisan support would be very useful.

The other thing is research. In terms of understanding what's popular and what's fun to play with at home, there are some fairly easy ways to do that.

You use focus groups, you try selling things on a sample basis, and you see what sells.

In terms of achieving specific educational outcomes, we have to have a better sense for what the right criteria are. Standardized test scores are fine if what you want to do is raise standardized test scores. If you want to develop other kinds of thinking skills, you need to be able to specify what those objectives are.

Once we have those, they'll be a target for the software companies to shoot for and that will be very helpful.

I don't think there should be one target. We need experimentation. We need, you know, thousands of flowers blooming to see what the free market does, to see what teachers want to adopt, to see what works in the classroom.

But I think there's a real role for the government in stimulating that without subsidizing it. The software companies don't want money. They'd like some other things that will help them produce for those markets.

Professor PAPERT. I want to say something directly on the question you asked about whether the kind of software that's accessible to your two-year-old child doesn't over value certain adult skills like learning numbers and so on.

I think——

Mr. ROEMER. Are you saying, doctor, that my two-year-old is smarter than I am already? Is that what you're saying?

[Laughter.]

Professor PAPERT. Well, I think——

[Pause.]

[Laughter.]

Professor PAPERT. Well, I've often said that one of the troubles with our education system is that we're trying to hurry along children to think like adults, whereas we'd do much better if we got more adults to think like children, and have a kind of creativity and intellectual honesty that we could all try to emulate.

But that aside, I think there's an important point here. That is, I think it's wonderful to see these kids doing that sort of thing. But something that concerns me is that there's a kind of emphasis on factual skills on learning these numbers, skills on getting the right answers, which the children enjoy. But I think that it's got some of the defects that have been identified with video games where you shoot—games to kill. Games to drill are often just as bad.

And what I would like to see, and I think it's a bit long to say why this isn't happening, but what I think will happen, what should happen is a kind of software environment where parents and children can engage together in common constructionist creative activities.

And my model isn't that the home computer which most of the software does, will take over the job of the teacher drilling the kid in how to add numbers, which I think is extremely unimportant for kids of that age to learn.

I think a better model is in the old days when fathers, supposedly used to buy these train sets so that they could really enjoy them, and that the model of the parent, the father and the child really working together on making a railroad layout, so they're really working together on a common thing.

I think this is the image that I would put forward. And I think this has to do with creating family solidarity around learning. I think part of this talk about generation gap, the answer to that is to say to parents, get in there with your kids. And respect them as teachers.

Chairman GOODLING. Mr. Ehlers?

Mr. ROEMER. If I could just conclude, Mr. Chairman, just to be fair to the software program that I quoted on Broder-Bond, they have about 12 different programs. About six of the programs are not numbers and alphabet, they are creativity. There isn't a right answer to give.

And out of those six, about two or three of them are games that you can play with your child, that I can get on the computer at the same time he can and we can play together, not at looking for one answer, but building things and using your creativity.

So already some of those things——

Professor PAPERT. Of course. I didn't want to say things are bad, but I think that's the direction where we need a lot more emphasis.

Chairman GOODLING. We, unfortunately, for the two panels who will be coming later, they'll be looking up here and wondering where everybody is, where everybody is, yeah, where everybody went.

And this getting the families together is wonderful. I'm all for it. I keep reminding everyone that there's a large percentage of dysfunctional families.

Mr. Ehlers?

Mr. EHLERS. Thank you, Mr. Chairman.

I apologize. I was gone for a little over a half hour. I had to give a speech elsewhere, and I would like to reserve my time at this time, until I get back into the sync of what has been said and what some of the questions are.

Chairman GOODLING. Mr. Cunningham?

Mr. CUNNINGHAM. Thank you, Mr. Chairman.

I'm very proud. I've got a nephew that just graduated last year from MIT with a scholarship in computer science. And I know the advantages of the programs they have.

Let me speak to the members of the panel as to the problems in California.

We have almost one in eight Americans lives in our State, and we've got across the nation less than 12 percent of the classrooms have a single phone jack to hook up.

I talked to AT&T, Bell, Corning, to see what it would cost to put fiber into different programs. And the problem is is that you can hook up every single school but AT&T I believe has got about 75

percent fiber, but the Baby Bells are limited, so right now, even if you hooked up all the schools, you could only talk school to school.

And there's a monumental problem in the things that we have to face.

What I would like to take a look at in the look site of the—chip, and 486s are now obsolete, why we have no invested in those systems. Why are we having regular school programs cancelled?

And again, I'd like to look at kind of a perspective of what our problem is in the State of California.

And I'm not saying this to inflame anybody in any group but to show why the revenue sources, in my opinion, are not there.

We talked about the school lunch program. I've got about 400,000 illegals kindergarten through twelve. There's actually about 800,000. I use the term 400 so they can't hit me on the figures.

But take the school meals program at $1.90, take just two meals instead of three, because they are 185 percent below poverty level, that's $1.2 million a day just on illegals in the school system.

Then I look, it takes $4,000 to $5,000 to educate a child a year. Take that times 400,000 and you're looking at $2 billion.

We've got 18,000 illegal felons in our prison system. Then you look at the children being born in the hospitals and the cost of increase in all the health care and stuff. That's one area.

The defense cuts, the $177 billion in defense cuts, base closures, have cost California over a million jobs in both military and defense-related. Ninety-three percent of education is funded through state tax dollars, so that's a million people there that are not funded.

Then we have the spotted owl for the timber industry. We've got the gnat catcher for construction. We've got the water and the salmon for the farmers. And all of these are jobs that are not paying into our education system to finance the things that we want to do.

And the end result is, with all the job losses, what do you have to do in the state? You have to raise taxes on the remaining businesses, and it's driving jobs out of California because of all of these different things.

Then we've got our own share of natural disasters.

And so what I'm saying is that we, especially in California, have got a monumental problem.

And the remaining seven percent of the federal, the question was asked, does the federal government have a role. Yes, but we only fund seven percent of education. But with that, comes 50 percent of the rules and regulations on the states that keep them from doing the things that we want to, and over 75 percent of the paperwork, which causes you to hire people and take dollars away from what we're trying to do.

I truly believe that on a bipartisan measure that we can eliminate a lot of these barriers, and work toward the things that we want to do.

I have a high tech fair. The tech is there. We hooked up computers with Paris, France, and the kids and the parents and the teachers dialed in and got the technology and talked in English and it was transposed over to French, and vice versa. And it doesn't have to be expensive.

I think some of my democratic colleagues have had a game called Challenge 24 in their districts. I mean, it's not high tech, but it's real innovative.

And I disagree with the gentleman that it's not teaching, it's just doing.

We just had the teachers' awards, our teacher of the year award, and I'll tell you what. There's some very innovative teachers out there in good school systems, from the highest tech schools on down the line.

But I know that the President just went through and conducted a PSPR swing through California. That's a "political speech and press release" swing.

And when they asked him—because he said he was going to put the computers and the technology into it, we asked him how, he didn't know.

But I would say to the gentlemen that we can. We can take off some of the controls that the federal government has, do away with the bureaucracy, solve some of the problems that I forementioned, and we'll have the dollars to invest.

We need industry. We need the AT&T and the Bells to invest. A profit is not a dirty word to this side of the aisle, and we need your help to coordinate that with science.

Thank you.

Chairman WALKER. Ms. Woolsey?

Ms. WOOLSEY. Thank you, Mr. Chairman.

Everybody who knows me on this Committee, knows that I believe education has to be the number one priority in this nation. And I also believe that we won't be able to achieve that unless we get technology in the classroom.

Fortunately, I represent an area, Marin and Sonoma County, just north of the Golden Gate Bridge, where Broderbund is established, Autodesk, George Lucas, Hewlett-Packard and many others on the cutting edge of technology development. So I'm very fortunate that I get to pick the brains of some very knowledgeable people on an on-going basis.

Just last week, I held a meeting in my district with 55 educators, users of technology, innovators, and technology manufacturers in my district. We sat down and we talked about the joint hearing today. We talked about what should be the vision in the year 2000 for technology in the classroom, and how long is it going to take to get there, and what we need to be doing.

We broke our discussion down into four parts: equipment and materials; training educators; infrastructure; and uses of technology. And in two and a half hours in the morning, I guess it was because it was morning, we really go going, we accomplished a lot.

And one of the things I want to ask you, and I'll start with you, Dr. Shaw, you're going to have this little baby girl in 11 days, are you assuming that she's going to be computer-able?

Are we going to assume that every child is going to be able to use a computer if we provide?

If the answer is yes, should we assume that?

Dr. SHAW. Well, I think we certainly assume that personally. My wife and I both use computers as a tool all the time. My Ph.D. is in computer science. But what I actually use the computer for is

probably what many of the people in this room use it for, as a word processor and for electronic mail, those are the main things.

Ms. WOOLSEY. So it's a part of your life.

But, I mean, we're assuming this child and every child is able to use a computer. One of the participants in my workshop last week was a student, a senior in high school, who has his own computer company—talk about a bright kid, he should be here too—and he said that every student isn't computer able and we're kind of making a mistake by assuming that.

But my next question would be, if we can assume that most students are going to be computer able, how are we going to start to ensure that every student has access, every student, not just those born to smart people like Tim Roemer here, whose kid's already smarter than he is.

We are so privileged here, but how about the less privileged? How are we going to make sure that every child, and this is one of George Lucas' visions, every child has a computer, not just in their classroom, but at home, like a book, has access, has the infrastructure, can stay current?

How are we going to do that?

Dr. KAY. Well, I think we can do that, but I don't think that's even really the point because we already have free public libraries all over this country, full of most of the content of our civilization, and most of the content of our civilization 4 years from now, in the year 2000, is still going to be in those libraries. It's not going to be on the Internet.

And I believe that we have a country that is very, very far from being reasonably literate.

Ms. WOOLSEY. Well, does anybody else want to answer to that?

Dr. KAY. Do you understand what I'm saying?

Ms. WOOLSEY. Yes.

Dr. KAY. I'm saying the access, we can make computers all over the place. We can make them cheap. We can hook kids up so everybody has universal access, but what I'm saying is they already have universal access to the stores of our civilization, and our educational system is supposedly set up to teach them how to make that connection, and it's failing at that.

So the calls of universal access to computers kind——

Ms. WOOLSEY. Well, I don't agree with you on that at all. That's an assumption that we start all over from scratch. Of course, we need to rethink a lot of things, but I want to move forward here today.

Dr. KAY. You want to talk about the new stuff instead of what we haven't been able to do with the old stuff?

Ms. WOOLSEY. Right. That's what we're here to do today.

Dr. KAY. And don't you think the same thing's going to happen?

Ms. WOOLSEY. I hope not.

Dr. KAY. You hope not.

Ms. WOOLSEY. That's what we're looking at. What's the best way to go further with this?

Dr. KAY. Well, okay.

Ms. WOOLSEY. One thing which concerns me is, do you believe that teachers should have to teach themselves? I mean, somebody said that, that teachers can teach themselves.

Dr. KAY. Yes, that's the only way you can learn.

Ms. WOOLSEY. Then we expect every teacher, without any support from the rest of us, to leave their classroom, go home, leave their kids, and go teach themselves?

I mean, don't we need to get our culture going in a direction that this would be part of their job, and that we provide them with support and assistance?

Professor PAPERT. I was the one who said about teachers teaching—I didn't say that they ought to. I said that they do, and that that minority of teachers, a substantial minority are doing a great job of learning.

Ms. WOOLSEY. Right, but how do we expand that?

Professor PAPERT. I think the problem is not to expand it. I think that the problem is to create some very compelling models that can set an example and change people's thinking. Unless you can change the whole public's thinking about what constitutes learning and what constitutes school, you are not going to get real change.

So I think the point is to make models and I don't know where.

I gave one example that break out of this K to 12 and use your own Job Corps that belongs to the federal government as a model where we can set up really innovative, different technology-based, technology-fluent learning. And that's just one example.

I think that we could change public opinion very quickly, not very quickly, it would take a few years, but of course that's the time that it needs to see effects but as long as we're tinkering with the system and trying to see how can you get whole school districts or whole states to do something, you can only do a common denominator that's pretty close to zero.

And it's all like—one more parable—it's like someone invented the refrigerator but only could afford one that would reduce the temperature by half a degree, and so everybody decided refrigerators are pretty useless things, and this is what we do generally in our experiments in education.

And it's not going to convince anybody.

Ms. WOOLSEY. We have a public school system—

Professor PAPERT. You have a condition where you could make some models. Well——

Chairman WALKER. The time of the gentlelady has expired.

Mr. Fattah?

Mr. FATTAH. Thank you, Mr. Chairman.

First of all, I really want to thank the panel for sharing their input. And I hope that the Congress will take much more of an interest in this matter.

The vast majority of our spending on education at the federal level has nothing to do with advancing the use of technology in education. Only a very small percentage of those dollars.

So if in fact, we've heard much of what you've said and what is in the literature today, maybe we'll do more about that.

It seems that in the near term future, though, we're going in the reverse direction. That is that the Congress is going to be taking action in this year's budget to actually be cutting some of the technology programs.

I'm thankful that yesterday we were able to announce a $5 million grant to the Philadelphia School District, my school district, to

move technology hopefully forward. But I'm fearful that that won't be the case in many other districts around the country.

I do want to say a couple of things and ask a question that I think that the ranking member, Congressman Clay, asked that really wasn't responded to.

We're not playing football against ourselves. We're not shadow boxing here. We are in a global competition which you talked about.

And in terms of our economic competitors, the response to his question in terms of a comparative analysis of our educational systems, especially as it related to technology, but in general, it was kind of like, well, we have a local model and they have a national model, and that was it. As if therefore there was no need to really make a comment about whether they are ahead of us, behind us, you know, achieving more or will be in the future.

And I think that we really deserve a response from such an enlightened panel on such an important question.

And I know that we've heard a lot today about a range of issues including dysfunctional families. We have a President and a Speaker who come from broken homes. They've managed to make it. Hopefully, we can help other children in our country, notwithstanding whatever position they start out in, to end up living up to their potential.

So I'd be interested in hearing about this comparative analysis with some of our economic competitors.

Thank you.

Dr. SHAW. If I could just say a little bit about that?

One of the things that's very well documented of course is that our country recently has not been doing so well, according to the measures that are usually applied. Those measures are very questionable, but I think it's fairly clear that it's not just for reasons of spending; our educational system hasn't been delivering what we'd hoped.

We spend something on the order of $6,500 per student, which is actually relatively high compared to many industrialized nations, and that places us fairly low in the rankings.

So there is an issue of why we're not getting more for our money. One thing to look at is the whole question of how much of that is going for research.

Just to compare this to the pharmaceutical industry, for example, America spends about $70 billion a year on prescription and non-prescription drugs, and about 23 percent of that amount is spent on research to find out which drugs are efficacious and safe to use.

Comparing that to education, at the state and federal and local levels, we spend a total of about $285 billion, an enormous amount, on education. Far less than one percent of that is spent figuring out what actually works in education.

And in fact within the Department of Education, because of the way the money has been allocated, they have a $30 billion budget, of which only about $50 million, a trivially small percentage, is used figuring out what actually works.

So part of what I think we have to do is to not just blindly spend more money, but to look very carefully at what we want to do in our schools and how we can do that cost-effectively.

And to make sure, as several of the members mentioned, that that happens on a universal basis. There are very serious equity issues. If we're not careful, we could exacerbate the differences between those people in our society who are most advantaged and those who are most disadvantaged. If we are careful about it, we may tend to close that gap.

Mr. FATTAH. I appreciate that, but my question is not about the comparative nature of our spending, or the—what I'm looking for is, in terms of the use of technology in advancing education, are the Japanese, are the Germans, are others doing better than we're doing? Are they about at the same place in this competition, if you will, in terms of developing the next generation of geniuses? Where are we at in this playing field?

Dr. SHAW. Yes. My understanding is that some other countries are spending more[2] to investigate some of these areas, but I think some of the other panel members may know more about some of what's going on there.

Mr. FATTAH. Please.

Professor DEDE. I've traveled to nine different countries for the U.S. Information Agency, looking at what they're doing with educational technology. And there are some very sophisticated programs in language learning that other countries have developed because they tend to be multilingual societies, that we could learn much from, and that would be important in terms of our global economic competitiveness.

But once you look outside of that area, by and large, they have been much more interested in the educational technology and the software that we've been developing than they have had things that they could share with us.

By and large, the world's software market is driven by American innovations.

Chairman WALKER. I would say to the members that we have a continuing long list of members and we do have several more panels. I have a list of people, as they've come in. We would still have four or five members to question this panel, and I will go in order.

I guess what I would ask is whether or not there are people who could defer from this panel to others, if possibly you can do that, we'd like to be able to get all of our witnesses on.

That's right. What we will do is in the next panels, we will go and take you in order, and so you will be first and anybody who reserves, as I understand Mr. Ehlers did earlier.

The next person on my list is Mr. Gutknecht.

Mr. GUTKNECHT. Thank you, Mr. Chairman.

I will try to be brief.

We've heard a lot about, and my background, I served in the state legislature for 12 years, and we had a lot of debate about, you know, computers in the classroom, and how much we should be spending per student and student to teacher class ratios and all of those things. And that's all interesting, and I think that all does have some impact.

[2] This sentence should read: "My understanding is that some other countries are spending more **on a per capita basis**. . ."

But frankly, and I think in the last discussion, Dr. Shaw talked about approximately $6500 per pupil unit is what we're spending nationwide.

But one issue that does not get talked about much, and it did come up, I think Professor Dede used the term a couple of times in his presentation to begin, the term "motivation." And I think that that's an area that we seem to sort of dance around.

But my observation has been that there are some kids out there who are just overachievers and literally, if you teach them how to read and maybe to use a computer keyboard, and turned them loose for 12 years, they would be fine.

But there's another group of students out there that somehow we're just not reaching, and it seems to be worse in some schools than others.

And perhaps any of you would want to comment on how do we, how do we tackle that problem? How big is that problem? And how do we tackle it, and what role can technology ultimately really play in getting to some of these kids.

And what I'm really talking about too, in part, is because I serve on the Washington, D.C. Oversight Subcommittee, and I'm concerned and alarmed about the schools here in this city.

And some might argue that we're not spending enough money, but based on some of the information we've seen, we're spending an awful lot of money on the schools here in Washington, D.C.

And yet, and I don't know how accurate this is either, but we're told that about half of the kids that begin in kindergarten will not graduate from the D.C. schools, and of those who do graduate, less than half of them will be able to read at an eight grade level.

So it's not money, and maybe they need more computers, but somehow I think somewhere along the line, we're losing that motivation link.

And I wonder if you would want to comment on that.

Dr. KAY. John Holt said that it would be so much easier to teach mathematics if we made it illegal.

[Laughter.]

Dr. KAY. So one of the ideas is that there's a kid's culture, and there's also an adult culture. And generally, children are very interested in learning things that are important in both of those cultures.

Sometimes people have advanced the idea that learning mathematics is hard, or learning science is hard, and that's why some kids don't do it, but shooting baskets is hard and there's a lot of failure in it. Hitting a baseball is really hard, and you fail most of the time. And most kids will almost turn themselves inside out to learn things that they think are important, even though there's an unbelievable amount of failure involved in these difficult things.

So many years ago, Maria Montessori, when she set up her schools, set them up in such a way as to let the children's own natural interest in what was around them, drive most of the processes. And then her job, she felt, was to design the environment so that the kids' collision with that environment driving on their own natural motivations caused the kinds of learning that she hoped would happen.

So you could say that the kids had wants and Maria Montessori had needs. And she was trying to collide those two together, so that the kids' wants provided the motivation and her needs were expressed in the apparatus that she built for the kids.

The MacIntosh user interface used Montessori's ideas so that as people try to do things, they also learn about many more things than they might have gotten out of a manual.

So this is an old idea that is a very, very good one. I think the hardest thing in schools is to make most of the things that schools try to teach be part of any kind of a society that children can recognize.

And sometimes the ones who seem to have the greatest learning problems are the ones who have figured out that it's a fake, the best.

Herb Kohle wrote an excellent little book called "I Won't Learn From You," and it was when he discovered that some of his students actually could read quite well, but they wouldn't show him that they could because there was much more going on than just a learning situation.

And so I think the motivation part really, the strongest thing we can do is to set up, as Seymour has pointed out, environment. When a child sees a teacher actually learning, rather than just teaching, or an adult, their parents learning about something, that's something they want to do. The children do want to do what the adults do.

But when they see teachers not wanting to learn, why should they themselves, unless they have that special spark that you were mentioning.

Professor PAPERT. I'd like to add a concrete example to that, and it's on the theme that everybody is motivated to do what they want to do. And a lot of kids think that video games are wonderful things.

Now there's a cheating way of using that by building into the video game that it's going to teach you the multiplication, but kids aren't dupes, and they don't fall for that.

Another way is to give kids the opportunity of making their own video games, by giving them enough access to computers and the knowledge and there's a lot of stuff. There's programming, there's how to organize a complex project, there's the geometry of movement.

We have seen, in a city, kids go ape about that opportunity to be able to make a video game. They are highly motivated and they learn an incredible lot of other stuff.

Only in order to do that, you've got to give up the idea that the way to learn is to fit into the school compartmentalization of knowledge because if you're making this game and you need some geometry in order to make something happen on that screen, you need it now when you've got the problem there, and not when it says in the curriculum that this is the day to learn that particular thing.

So this involves a radically deep restructuring of our thinking about what school is about and how we do things there.

I think that those kids you're talking about, it's not that school has failed to motivate them, school has demotivated them because what you do in school is fundamentally boring.

And it matches some people's intellectual style to do that, and those kids do well.

The others are profoundly discriminated against and I guess it's only a matter of time before somebody will see this as a constitutional issue that school is, in itself, a profound discrimination against everybody whose intellectual style doesn't happen to fit that very systematic, subordinating way of learning.

Professor DEDE. Another piece of this is social. There are kids who are not going to be very interested in objects, but to the extent the technology can become a social medium for them, it can provide a focus for collaborative learning, it can provide a focus for reaching across distance into a virtual community, and that's a very important part of motivation.

Chairman WALKER. The time of the gentleman has expired.

We were just talking up here. We think that maybe there's already a term in education out there for it. It's called "attention disorder."

[Laughter.]

Chairman WALKER. For the civil right that you're describing, Professor.

The next person is Tim Petri.

Mr. PETRI. I want to thank you very much.

And going through my mind, as I listen to the testimony and the questioning is, what the federal government can do at the end of the day that is helpful and what it should avoid doing that is counterproductive or actually harmful.

And in that connection, I'd appreciate your comments on that because it's been my impression, serving on this Education Committee for some years now, that we have a lot of very good intentions and we come up with a lot of very good programs, but at the end of the day, they are run through a bureaucracy which, whatever the premise or purpose of the issue is, has the net effect of diverting people's attention, empowering people who don't really understand what that good intention is, but do understand filling out a piece of paper or hiring more people to regulate the flow of money, and we've just built a big, bureaucratic machine, with best of intentions which may in fact be part of the problem.

And so I don't want to see us, unless you guys think it's a good idea, to use the rationale that we need to have more modern technology, we need this new thing in the education system, so let's set up a big program and hire some more people who probably will do no better than we've done with three or four other major national pushes in this area.

Could you comment on that?

We want to be helpful, the federal government, but we do have some clear problems in education and whether doing it top down, beyond the pulpit, is really constructive or not, is something I'd like to know.

Dr. KAY. Well, I understand future in this town means two years. [Laughter.]

Dr. KAY. But it's going to take a little bit, so a short-term kind of thing that might help would be something like the following.

The successful, widespread of powerful ideas in some school districts I've seen, for instance, the Pasadena School District has one of the best elementary science programs that was done by a couple of scientists at Cal Tech, kind of in their spare time, and it got bigger and bigger and better and better, and more organized and it's in the whole school district for the last five or six years, and it's really excellent. And they had to do it without being able to turn any of the elementary school teachers into scientists.

But what they did is they, and this is, you'll find I think if you go around the country, you'll find very similar structures and other successful areas.

What they did was they came up with a combination of what the elementary school teachers do in the classroom, combined with district circuit riders who were scientists, who really had a sense of this, and basically what they wanted to do was to have daily activities that were bolstered by two-time-a-week visits by somebody who could assess the quality of what was going on.

And I was involved in one of these with music that I put in one of my written documents, where the entire school district had to become musicians because it was a small high school and they wanted a full band and an orchestra and a chorus. And so they just taught everybody to be musicians regardless of talent, and the school teachers had the same mixture of talent as anybody else did. But they had an excellent music coordinator. And the whole thing worked very well.

And this used to be a popular way of doing things like art and music and science and so forth 40 and 50 years ago. Many states have cut the people for those people, those curriculum experts who traveled around and helped the teachers.

I think that would be something that would not cost a lot, that would make an enormous difference in the short term.

I think in the longer term, you really have to think about restructuring the whole nature of school and what we think of as schooling in this country.

Professor PAPERT. Well, I've got one suggestion and that is that you get somebody on your staff to really get involved with a lot of time and discussion about, on the long term, about how things, what real radical change might look like. There's not enough time to do it here.

Alan Kay and I were talking, before this meeting, about creating a forum for this in cyberspace. Say that. And just as a start, on my written testimony, there's an address in on the web which I think we might be able to use as a starting point for that, so call in and get somebody on your staff to devote a serious amount of time to trying to get engaged in a discussion about how—

Mr. PETRI. What is that address again for anyone who might be watching?

Professor PAPERT. What?

Mr. PETRI. What is that address again?

Dr. KAY. It's right above, you don't want us to say it to you.

Professor PAPERT. Right. You all get this, don't you?

Dr. KAY. It's right above where it says "recommendations."

Chairman WALKER. Why don't we read it?

Dr. KAY. URL:http://el.www.media.mit.edu/groups/el/projects/school

Professor PAPERT. You've got a techie on your staff who'll understand that.

Dr. KAY. You'll only have to type it once.

Dr. SHAW. If I just have a minute to add something to that? Or do we have the time?

I think that's a wonderful idea. I think the idea of having a presence on the Internet would be a terrific idea for many reasons, both for people involved with public policy and for teachers and students.

And as Professor Papert said, I think that that's something that's likely to be inexpensive and immensely valuable. I think that's a great idea.

In terms of the longer-term funding issues, the last thing that I personally would like to see is a massive federal program where money is thrown at the problem without thinking of things that we actually have evidence will work.

I actually think that the vast driving force here should be the private sector, for the development of the underlying technologies, which are bound to happen in most cases anyway. There are other commercial drivers. And in the case of educational software, I think there are relatively limited areas, though there's tremendous opportunity for the federal government to leverage those areas.

One of the main ones is in research. And in order to make sure that we don't have a top down solution that generates worthless stuff, I think one of the best things to do would be to have a series of small, relatively low-funded, but a reasonably large number of investigator-initiated early stage research projects, so that the free market of ideas could help to find which solutions actually take.

I think in the long run, realistically, we're going to need some large-scale trials. It's very easy for scientists to fool themselves and think they have a result, especially when there's an emerging new paradigm that everybody believes in.

And so we're going to need some of that. That will cost something, but we don't need to do all of that immediately.

I think in the long run, we really want to rely very heavily on the private sector, and on volunteerism as well, and then leverage it very carefully with federal support.

Chairman WALKER. The time of the gentleman has expired.

Mr. Foley?

Mr. FOLEY. Thank you very much, Mr. Chairman.

And I just want to state that this is probably the best panel I've heard since I came to the 104th Congress.

Honestly. Because the key to the problems we face in our society are being answered by the panelists. The problems we face, the crime, the illiteracy, the abuse at home can all be solved if we would take some of the great input we've had today.

Professor Dede mentioned about parents dropping kids off as if it's laundry. That's happening in our schools today. They assume there's no responsibility after 8:00. It's the teachers' problem.

I talk to teachers in the school system. They describe themselves as babysitters, counselors, police officers. I mean, that's not educators, that's being guardians or custodians of problems of children.

The exposure to technology we've talked about. If you go to a Head Start program and watch children, two and three-year-old children playing with computers and working on stereo equipment, it's phenomenal their grasp of these technologies that my father, when I show him a new VCR, he says, how do you start it, what do you do, how do you set the time. Put a four year old, and the kid will dial it up because they've been exposed to something.

Dr. Shaw had highlighted your comments on the percentage spent on discovering new—$50 million for the Department of Education's $30 billion budget allocated to research. Clearly we're not going anywhere because we're not spending the money in the right areas.

Pratt Whitney, a company in my district, has 20 students from disadvantaged homes working in their plant on high tech projects, learning, focusing on responsibility, and coming away with a knowledge and, more than anything else, a responsibility. They have a day time opportunity to show up at 8:00 o'clock and leave at 4:00 and get paid for it, but learn something about the high tech world in which we live.

The School of the Arts in Palm Beach County teaching children much like those operating the C-SPAN cameras today, how to work in the technology broadcasting, broadcast journalism, dancing, theater. I mean, these aren't traditional school programs by and large, by academicians, but let me tell you there's zero incidence of crime in those schools against teachers, against children, against property, because they're doing something God gave them a talent to do. They're exploring the new world in which we live.

Professor Papert mentioned things. Let's shake this place up.

We are sitting in a time and place where teachers report to work, there's union rules, the students are told to sit down and shut up, you know, and our answer sometimes, well, if we take a minute to pray, then the society's going to get better.

[Laughter.]

Mr. FOLEY. What we need to do is shake up the system. And we have got to push every button we can. And I'm glad Mr. Walker, Chairman Walker brought the Education Committee together, because I think science is the fundamental reason.

People say, Mark, you shouldn't spend money on Space Station. That's our learning environment. That's our future. That's our nation's opportunity to get kids out of the gutter and into opportunities for their future.

So all I can tell you is I am thrilled, I'm thrilled about all of these suggestions. But I pray that we don't just shut the lights off and go back to our jobs and say well, that was nice. Because if we don't rock the foundation of education, we keep spending more and more money to do the same old, same old thing.

And I agree that one classroom concept. Why keep a kid in second grade when they have the aptitude of a fifth grader? Put them together and then they'll learn to be an eighth grader within the sixth grade.

And pretty soon you now have students leading students. It shouldn't be the teacher standing up, follow me, do as I do and as I say. It should be the students saying, come explore with me this opportunity of education.

I just, I have so much hope and promise for this nation, but if we don't direct the resources to research, to improving education and making our kids able to focus outside the box that they're put in, then our society will stay static and our crime rates will increase, and violence against women will continue because they don't know anybody.

And I'm just, you know, I can't say enough about this panelist group, because I think we should take verbatim their transcript and send it to every member of Congress, every principal in every school system in America, and say, folks, wake up. When the bell rings, it doesn't mean act like a robot, it means act like a person that can instill in the children of our country the opportunity to learn.

God bless you.

Professor PAPERT. Come join our forum.

Chairman WALKER. Thank you, Mr. Foley.

What I'm going to do here is, we have members that continue to come in and out of the room, and that extends. I'm going to go to two people who've been here throughout the time, that came in early and so on, and then dismiss this first panel.

Mr. Weldon was here earlier. I'm going to go to him, and I'm going to go to Mrs. Johnson, and then I'm going to shut it off for this panel and go onto the other one.

So I recognize next Mr. Weldon, and then Ms. Johnson.

Oh, okay. Mr. Baker was here as well. All right.

Okay. Well, Mr. Weldon first.

Mr. DAVE WELDON. I thank the Chairman.

I have a lot of interest in some of the things you've all been talking about, particularly in regard to some of the things my colleague from Florida was just saying, challenged the whole structure of education.

I educate my eight-year-old daughter at home. I discovered many years ago that children in home education do actually quite well, and their social skills are actually superior. And that was actually one of the things that interested me in home education.

When I was in the Army, I got to be good friends with two officers who had children that they home-educated, and I noticed that there were some peculiar things about their children. They didn't dress in a bizarre fashion, they didn't wear their hair in a strange way, and when you looked at them, they actually looked at you in the face, and if you said hello to them they actually said hello back, and they didn't look up at the ceiling and walk away. And they were fairly well-behaved and seemed to be well-adjusted.

And to me, just from my perspective, the whole concept of taking a bunch of seventh graders and sticking them all together, and a bunch of eighth graders and sticking them all together, may actually be a faulty concept.

As I understand it, there are some research studies that have shown that students in those old-fashioned schools where they were all mixed in in all the grades actually academically do better.

And do we really need to fundamentally rethink how we do education?

I know for my wife and I, we're using a lot of high tech stuff. We're using videos, we're using computers. Though I will say, I think it would be inappropriate for us to oversell this stuff.

One of the things I've noticed with my daughter is she really loves those math programs when I sit down next to her, when she's doing the math programs, and parental involvement. You know, they say in real estate, it's location, location, location.

I think in education, it's parental involvement, parental involvement, parental involvement, and we could talk about all the newfangled stuff, but if you don't have parental involvement, forget it.

You can have the best programs and all the best computers and, so any comments?

Dr. KAY. Well, I think the simple line is, all schooling is home schooling. When a child goes away to school, you could think of the school as the research center, where they find out about things, that things exist that they don't know about at home.

But I think most of the learning that children actually do is done at home, whether they go to school or they're home-schooled. That's where they do it.

And all of the successful systems of education that I know about have had a strong notion of parental responsibility.

Also, I happen to think home schooling is a good idea in general. It's more efficient, the kids have more of a chance to do projects. There are lots of good reasons for it. But to me, the motivation that you mentioned why your daughter wants to do those programs is the main motivation for why kids want to do most things. They want to be like adults. And they need to have adults that they want to be like.

Mr. DAVE WELDON. Well, I'll yield back the balance of my time for the sake of efficiency, Mr. Chairman.

Chairman WALKER. Thank you, Mr. Weldon.

Ms. Johnson?

Ms. JOHNSON. Thank you, Mr. Chairman.

I just have brief comments.

It is no secret that, you know, education is the real foundation for the future of this country. And I wonder, I'm sorry I didn't hear all of your testimony. I was detained in another meeting, but when and how can we make sure that every teacher becomes comfortable with the available technology, rather than computers just being in the computer classes.

That seems to be a problem in my general area. I don't know whether it's a problem other places, that the teachers don't want to deal with the available technology.

Professor DEDE. When I work with teachers who are not interested in technology, I get good results by talking to them about their love of children and their love of their subject, because there are many teachers now who enter teaching because they love children, but who feel cut off from their students by the structure of the traditional school.

Or who entered education because they fell in love with their subject, but now are cut off from that by the structure of standardized testing.

And to show them that there are new models of learning that are possible that may take technology to implement, but that reestablish that kind of relationship with learner and with subject and with resources outside of the school, gets those teachers very excited, not about the technology, but about the new model of learning.

And I think that that's the key to involving teachers. Teachers are very interested in learning.

Ms. JOHNSON. Thank you.

I've found that teachers are very interested in learning, but also very intimidated by some of the technology.

In terms of educational opportunity, it has been my experience that when teachers do show that interest, notwithstanding what the student looks like, the student is in an environment that they have an opportunity to learn better.

Now, but students do have to see the value of education. When they see that their parents go through college and high school and don't have opportunities, I have been challenged in saying, why should I do it?

I see my father suffering through this everyday. How do we approach that type of problem?

Dr. KAY. Well, that's kind of your job, isn't it?

Ms. JOHNSON. I try, but I'm in the minority.

Dr. KAY. No, I think it's just really—I was talking about Congress—I think it's a really hard problem——

Ms. JOHNSON. I was too.

Dr. KAY. And I can't really——

[Laughter.]

Dr. KAY. Oh, okay. I thought you were asking us a question that we're supposed to——

Ms. JOHNSON. I thought you might make us some suggestions in front of God and everybody.

Dr. KAY. I think the problem of having somebody go through college and not being able to get a job is a question I can't give an answer to. But I think to the question——

Ms. JOHNSON. But how do you convince students, the children of these parents who are having these problems, that education is worth it?

Dr. KAY. I don't know, but maybe Seymour does.

Professor PAPERT. I just started to say something about a way in which that question is badly formulated because when we say education is worthwhile, aren't we saying to this little kid, do this because in 12 years' time, you're going to get a job. And the kid isn't a dupe. The kid knows that's BS.

On the other hand, every kid is interested in something, is desperately, deeply, passionately interested in something, and there isn't any content that couldn't be used as a means of coming into of getting at powerful ideas, getting at deep skills of how to run projects, how to do things.

The trouble with school is that it calls itself education and pretends that anybody can be, quote, motivated by what's going to happen in 12 years' time. They're not.

We can restructure the learning environment so that people can learn from what they're interested in.

Now this doesn't mean they can do whatever they like. It doesn't mean we don't have standards. It doesn't mean we don't insist that they work hard, but it does mean that we apply intellectual effort to identifying the kind of powerful ideas that can be accessed through these activities.

And apropos of that, I'd like to add to David Shaw's criticism of the small amount of research that's done in education. As he said, research in education often means finding out whether it works or not, but if you compared that with what happens to drug companies, only a small amount is finding out whether it works or not; most of it is finding the stuff that works.

Dr. SHAW. Yes, that's right.

Professor PAPERT. And in education, it is almost impossible to get funding for finding out new things, as opposed to well, here, we've got this model and we're going to do a controlled experiment to find out if it works.

We need to create new forms of knowledge.

Ms. JOHNSON. Thank you. My time's expired.

Chairman WALKER. The time of the gentlelady has expired.

Mr. Baker.

Mr. BAKER. I'd like to follow up on Mr. Foley's comment, and you can never come to a hearing where you don't learn something, and I was very amused by the Professor's comment regarding the refrigerator.

We only have to look on the wall here where in Proverbs, it says, where there's no vision, people perish.

You said if you invented a refrigerator, but tell people it's only going to lower the temperature one degree, who would buy it?

And we're in education, we've been in education now for 50 years, and we say if you just give us ten more bucks, we'll make it all better.

Same broken system, just pile more money on top.

So here's what we have. We have a group in Milwaukee working among the poorest students in the world, financially poor. Potentially they're rich, but they're poor students. They don't have a background of education, they don't have two parents with Ph.D.'s. And they want to have charter schools. They want to try something new.

Well, after the unions get through with them, the court system steps in, and they'll be 120 years old before they can try an experimental school.

And so when you say we need a new refrigerator that does more than lower it one degree, are you right. We've got to experiment, we've got to have vision. We're the only nation in the world that teaches one language poorly.

[Laughter.]

Mr. BAKER. And we say, just give us more money.

Nationwide, as someone mentioned, we're spending $6500. That's only $180,000 a classroom. That's bureaucracy. The teacher doesn't make a $180,000, the kids don't get paid to be there. Where's that money going?

And can we hire three nuns with three rulers and say, build us a better system? Yes, we can. And we're not allowed to do it.

This is a static, this is the most static world in e world is education world, and it should be the freest.

Would you like to comment on that crazy idea?

Dr. KAY. Well, I'm not sure the three nuns with the three rulers is quite the way you want to go.

[Laughter.]

Mr. BAKER. It's the way I want to go right now, but I'd like to turn them on Congress.

Any other questions?

I'm going to yield 30 seconds to Duke when you're through, Professor.

Professor PAPERT. What you say is absolutely right, that we can't go throwing more money at people who are going to make minor changes to the same system, and that's been the moral right through.

We've got to find a way of fostering very different innovation, and those people, you need to find some way not to send three nuns out, but to enable your people in Milwaukee to be able to do their experiment, and surely that can't be beyond the Congress of the United States of America.

Mr. CUNNINGHAM. Just a quick one, and I would make a comment to Ms. Johnson.

One of the most difficult things I had to do in a squadron was to get senior chief petty officers and master chief petty officers to use a computer after doing it with a pencil for 25 years.

My master chief was computer illiterate. We mandated that every one of the chiefs went to National University to become computer literate, and you saw it take off from there, the petty officers, and it went right on down the line.

So recommendation. Get someone that's fired up about it to show them how it saves time and I think it'll help.

Mr. BAKER. I yield back.

Mr. CUNNINGHAM. Thank you, Mr. Baker. I appreciate it.

Chairman WALKER. With that, we will thank the first panel. It was an excellent panel, very lively discussion, and I'm delighted with what we got. We thank you very much for participating and invite the second panel to join us at the table.

What I'm going to do to try to make time work a little bit better here, what I propose to do is to take the names of members that are in the room as this panel is testifying, as they come into the room, and anybody who's in the room while the panel is actually giving their testimony will then be called upon for questions.

People who come into the room later on and so on, we will save for the next panel. So we will try to make certain that the people who asked the questions are the people who were here for the testimony.

We welcome each of you here and thank you for coming.

I'm going to again go by my chart. It kind of goes the other way this time.

We'll start with Mr. McCracken and Mr. Wright, Mr. Mendenhall, and finish up with Mr. Joseph.

Mr. McCracken, we would invite you to give your testimony. We thank you for being here. I understand that you could be traveling

other places today, and decided instead that this was important enough for you to do, and we thank you very much for being here.

STATEMENT OF MR. ED MCCRACKEN, CHAIRMAN AND CEO, SILICON GRAPHICS, MOUNTAIN VIEW, CALIFORNIA

Mr. McCRACKEN. Thank you. It's a pleasure to be here.

I'd like to ask for permission to submit my prepared statement for the record.

Chairman WALKER. Without objection.

Mr. McCRACKEN. And I have five points I'd really like to talk about today.

First is we must prepare our children for the information age. We're somewhat overwhelmed today by what's happening with technology and how rapid the change is, but by the year 2007, and 12 years from now, when children entering our school system, graduate from high school, there will be a one thousand times change in what can be done with computer systems in terms of price and performance.

That means that systems that cost a million dollars today will cost a thousand dollars in the year 2007. There'll be an equivalent change in the speed of communication, which means that instead of just having voice communication, we'll have inexpensive pictures, video, interactive games, virtual reality over the network.

And what that means is that we'll have the capability that the designers of Jurassic Park and Forest Gump and Pocohontas, we'll have those capabilities. We'll have the capabilities the designers of the Ford Taurus and the Boeing 777 had available to us for just a few hundred dollars, typically under five hundred dollars in those days.

Our country's economic competitiveness will be determined by our mastery of these tools.

There's a term that the Yankee Group in Boston uses to describe children, a certain type of children, they call it Tafies. It's used to describe children of "technically advantaged families."

I know my kids are that way. I have an art student daughter who uses computers to do her art. She passes that around over the net. She also does her banking on the net and keeps track of 20 to 50 friends continuously over the net. Those are tafies, children of technically advantaged families.

I believe that schools are the only way to give all Americans a chance in the information society and equal opportunity in the information age.

An example of that is in Silicon Valley where I come from. Today, an increasingly high percentage of all job postings occur on the network. If you're not wired, if you're not part of the information society, you just don't know about the new jobs.

The second point I'd like to talk about is that we need a national initiative. I've had the opportunity, over the last two years, to co-chair the President's Advisory Council on the National Information Infrastructure. This 37-member council has had the opportunity to conduct hearings around the country. We've deliberated many issues.

But we've determined that the best way to kickstart the country into the information age is to ensure that every child in America

has access to the data super highway in their classrooms and libraries by the year 2000.

We've learned of course that you not only have to master the information tools, but these same tools can be used to master mathematics, reading, and they have a tremendous impact on simple things like school attendance and the excitement about learning, as we heard in the last panel.

The third point I'd like to make is that these technologies are affordable. One year ago, the council commissioned McKinsey, the consulting firm, to study the costs associated with schools and the information superhighway.

In a soon-to-be-released report, they indicate that schools can be outfitted with one classroom with computers, complete range of computers, for about two percent of the total educational budget, and that every classroom can be outfitted with computers connected to the Internet for about four percent of total educational spending on an on-going basis.

This includes the cost of technology, the cost of support, and also teacher education.

This brings up part four, which is teacher retraining. The most significant cost in this study is not hardware, it's not network capability, but it's teacher reeducation. It's the most significant issue.

The educational system today offers little incentive to encourage teachers to acquire and apply technology skills. And state credentialing requirements in most states do not require it.

Teacher/college training programs do not require it for graduation. And in-service training programs need to be revamped to develop and reward technical skills.

Today's teachers have little computer experience. Quite often, they've opted to go into teaching to avoid technical education, and we need to make a substantial change in this area.

Finally, we learned that there was a significant commonality between all of the projects we saw in this area that were successful, and that was inspired local community leadership.

As we traveled around the country visiting schools using computers, we found one common factor: individual initiative and local leadership from parents, teachers, administrators, business people and others.

And an example of that is in Silicon Valley where local business leaders have contributed $20 million to be spent over the next three years to improve the education in Silicon Valley schools using technology.

I urge each of you and your colleagues to help kickstart this effort in your own districts. You and your constituents have an opportunity to accomplish something that will benefit all of our children and prepare us for this information age in the 21st century.

I actually bring a message of hope. I believe we can do this.

[The prepared statement of Mr. McCracken follows:]

SiliconGraphics
Computer Systems

Statement By

Edward R. McCracken
Chairman and Chief Executive Officer
Silicon Graphics, Inc.

Before a Joint Hearing of the Committees on
Science and Economic and Educational Opportunities
U.S. House of Representatives

October 12, 1995

Mr. Chairmen and Members of the Committees:

Thank you for inviting me to participate in this hearing about the impact of technology on education in America over the next 20 years.

Let me start by sharing with you an example of how technology can fundamentally transform an organization's culture and way of working. At Silicon Graphics, we are using the World Wide Web to change how we communicate with each other and with customers and suppliers. It alters how we access data, train our workforce, collaborate with partners, and communicate with our offices around the world.

Education has not yet realized how it can benefit from the fundamental impact of technology, as many other institutions have. This is no one's fault, but it's everyone's responsibility to see that our educational system has what it needs to prepare world-class students.

When this happens, students will have access to more information, a broader selection of teachers and more communication within their communities and with other students around the world.

Teachers will have more resources to educate their students and will be able to tailor their teaching to each student's needs more effectively.

Many people are skeptical about whether technology can improve learning. But research studies and anecdotal evidence from pioneering schools show dramatic advances in learning with proper use of technology.

Connecting students to the expanding world of on-line information helps students to master technical and vocational skills and to achieve significant improvements in academic performance.

For example, one review of 130 recent academic studies found better student outcomes in language arts, math, social studies, science, foreign languages and other subjects.

Another review, of 254 controlled studies, concluded that appropriate use of computers in classrooms reduces the time needed to master certain types of knowledge as much as 30%. In three

years, students with computer- assisted instruction can learn almost a full year's more material than students who do not have access to technology.

Many schools have experienced significant improvements in student performance after introducing computer- assisted instruction. For example, the Carrollton City School District in Georgia reduced the failure rate in 9th grade algebra from 38% to 3% after establishing a computer lab, among other changes.

In New Jersey, the Christopher Columbus Middle School found that student performance rose from well below to above state averages on standardized tests in reading, language arts, and math after the school implemented reforms that included extensive use of networked computers.

Furthermore, case studies suggest that when the technology is integrated into the curriculum, it can support new teaching methods that emphasize critical thinking and investigative skills.

For example, California's Hueneme School District found that their student's average critical thinking abilities increased from the fortieth percentile to the eightieth percentile over the 12 years that the district has been integrating educational technology into its classrooms.

Just as importantly, electronic mail, video conferencing, and voice mail enable students to communicate with teachers at other schools and colleges, with experts in museums and research institutes, and with other students around the world.

Parents and other community members can become more involved in the educational process, as well, by dialing into the local school network from home computers. Or they can use equipment in local libraries, community centers and the school itself.

At a minimum, using the wide array of available technology promotes computer literacy and networking/information skills that are required for an increasing number of jobs. By the year 2000, 60 percent of American jobs may require technology skills.

As a businessman, I can't overstate how critical it is for our nation to ensure that our children, today and in the future, are prepared to take these high-skilled jobs so that America remains globally competitive.

But to reap these learning benefits from technology, we will need a number of components, all working together and reinforcing one another. Two of these, I believe, are not hard to ensure: appropriate and affordable technology; and children ready and willing to learn.

As chairman of Silicon Graphics, the leading visual-computer company, I have seen technology prices decline and technology performance improve more than 100-fold just in the past seven years.

As a technologist, I can assure you that this pace of innovation will continue. I foresee a time in the near future when $500 multimedia computers will be available for schools wanting to get on the information superhighway. And I believe that good and affordable technology will be readily

available.

Likewise, children are already willing and excited to learn with new technology. As most of you know from your experience with children and grandchildren, children adapt more easily and enthusiastically to technology than most adults. In every classroom I have visited, I have seen students excited and engaged when they use technology.

What a difference that can make! For instance, at one school in Georgia, dropout rates fell from 19% to 5% after the introduction of technology in the curriculum.

Why not increase this natural motivation by offering every child in America the chance to drive on the information superhighway? I envision granting each child a driver's license for the superhighway, as a reward, as soon as they are able to:

- access an on-line service;
- collaborate with students in other countries on their favorite subject;
- connect with a scientist on a real-world research project;
- work with a team to complete a math project and share answers with students across the country;
- visit the great museums and libraries of the world electronically; and
- research the flow of a bill as it goes through Congress.

With this incentive and recognition, students would be enthusiastic drivers on our information superhighway.

So, technology and students are not holding us back.

Yet few public schools have assembled the required elements of technology to improve learning. While, on average, there are 14 multimedia-capable computers per K-12 school, distribution of these computers is highly uneven across schools.

Although up to 50% of schools have already installed local-area networks, less than 10% of these networks connect computers in classrooms. Most just connect administrative computers. And while almost all schools have telephone lines, fewer than 3% of classrooms have a phone line.

Why aren't we moving quickly to take full advantage of technology in education? I think there are three challenges we need to address so that we can move faster:

- funding
- teacher training
- courseware

The first challenge is funding. McKinsey & Co., management consultants, have developed some valuable information about technology and education. Depending on how much technology is deployed, and how quickly, the cost of equipping public K-12 schools could range from 1.5% to 3.9% of the total K-12 budget nationwide during the peak year of expenditures.

By comparison, 1.3% of the public K-12 budget is spent on similar technology today. Keep in mind that is an average. Some districts are spending far less, others more.

It should, nonetheless, be possible to meet the funding challenge through a combination of cost reduction, re- programming existing funds, and additional initiatives from the public and private sectors.

In the area of cost reduction, for example, steps such as bulk purchasing taken at the state or national level, could get lower prices than a typical district could get by itself.

In addition certain categories of the school budget bear some relation to spending on technology infrastructure and thus might be re-programmed to support connection to the information super-highway. For instance, a portion of the textbook budget might be shifted to acquiring on-line instructional materials.

Finally, innovative schools across the country have secured funding through partnerships with corporations and community organizations.

The second challenge is to provide incentives, training and support for teachers to use technology effectively in the classroom. Teachers play the pivotal role in integrating technology into the curriculum and facilitating its day-to-day use. But nearly 50% of today's teachers have little or no computer experience, much less the training and confidence they need to fully integrate networked computers into their classroom teaching.

The educational system offers little incentive to encourage teachers to acquire and apply technology skills. Incentives will need to be created. And state credentialing requirements, teacher-college curricula, and in-service training programs need to be revamped to develop and reward technology skills.

Further, teachers have not received appropriate levels of training and support in using technology. Few universities offer significant training or experience in the use of technology in the classroom as part of their education curricula.

Most in-service training is too brief and has no follow-up in the class room. And teachers are given too little time to work together on developing new approaches using the technology and to support and learn from each other.

The final challenge is removing the disincentives that are slowing the development of educational software or "courseware." Meeting the diverse curriculum needs of all public K-12 schools will require a very broad assortment of high-quality courseware.

Currently, production of such courseware is limited, because the educational market for such products is still relatively small. One can compare the $290 million market for courseware to the roughly $1.5 billion market for "edutainment software" for the home. Software developers are quite pragmatically putting the vast majority of their resources on the home market.

This decision is reinforced by software companies' experience with the bureaucratic and costly purchasing process in most school systems versus the efficient, retail distribution system for home software.

Widespread commitment to integrating technology in K-12 schools would spur growth of this market, which in turn would speed up production of high-quality courseware. In addition, public school budgeting and procurement processes could be streamlined to accelerate adoption of new courseware. This would also make it easier for courseware developers, especially smaller, innovative companies, to enter the public-school market.

We need to change all of these elements in concert if we want to change teachers' behavior and performance in the classroom.

These three challenges can be met if we marshal leadership. It will require sustained efforts and contributions of leaders at all levels -- school, district, community, state and federal. In each school and district, it will be necessary for local leaders to communicate a compelling vision, set clear goals, and generate enthusiasm for connectivity.

Change can be difficult and unsettling. Sustained, visible, committed and caring leadership is essential to give people direction and confidence to proceed.

In addition to the work that your distinguished committees and others can do at the federal level to provide leadership and support, I believe that it is crucial to kickstart leadership at the community level.

The National Information Infrastructure Advisory Council, which I co-chair, will soon release its KickStart report. This broad-based, diverse group of 37 business, government, education, labor and other community leaders will issue a call to action and provide a guide for every community in America.

Then, we will need to encourage local leaders to take the initiative to put this revolution in learning technology to work in school, libraries, and community centers across America.

Strong leadership has been a key success factor in every case study we examined. Local leaders at innovative schools like the Ralph Bunche School in New York City, the Carrollton City School District in Georgia, and the schools in California's Hueneme District, just to name a few, have pioneered the way. Students in these schools are already profiting from the educational benefits of technology.

Actively encouraging experiments and initiatives such as these in many more schools and districts around the country could result in widespread and significant improvement in American education - a true revolution.

I urge each one of you and your colleagues to help kickstart these kinds of efforts in your districts. You and your constituents have an opportunity to accomplish something that will benefit all of our

children.

The technology is available. Pioneering schools and teachers have proven that it works. The funding, even in this difficult budgetary time, is within reach. The know-how is available to help teachers develop new teaching approaches and to build the needed software. The scarce commodity is leadership. We owe it to our children to provide that.

Thank you.

Chairman WALKER. Thank you very much. Appreciate it.
Mr. Wright?

STATEMENT OF MR. PAT WRIGHT, VICE PRESIDENT, TCI EDUCATIONAL TECHNOLOGIES, INC., ENGLEWOOD, COLORADO

Mr. WRIGHT. Good morning, Mr. Chairman, and members of the Committees.

My name is Pat Wright. I'm Vice President of Educational Technologies for Telecommunications Incorporated, TCI.

Our nation's elementary and secondary schools are facing enormously difficult challenges. Bringing about lasting change for the better will be a complicated process requiring difficult choices in the public and in the private sector.

Technology can and will make an important positive contribution.

Technology's transforming all our nation's institutions. This transformation's being driven by the convergence of three critical developments.

First, fiber optics, which has become the most cost effective broadband communications infrastructure.

Second, high speed microprocessing, which allows all kinds of digital processing at very low cost.

And third, operating systems software that links personal computers via high capacity digital networks.

When coupled with the digitization of print, audio, and video, this technological convergence makes multimedia and interactive media more than just buzzwords.

TCI's committed to making education one of the first direct beneficiaries of this technological transformation.

Technological advances are beginning to transform our educational system from an industrial based model to an information-based model.

The new information-based model eliminates the barriers of time and location.

In today's education system, students must be ready to learn when teachers are ready to teach. And they are limited to the classroom environment.

Technology unbinds the educational experience. Learning will take on a whole new look and feel.

What we are likely to see is real time presentation, on-line conferencing, and artificial intelligence that will allow students to access high quality, interactive multimedia resources where and when they are needed.

This is the 21st century version of the old Zen proverb, when the mind is ready, a teacher will appear.

Equally important, technology will allow students to draw expertise from many sources simultaneously. Courses of the future will combine the expertise of many teachers and other experts electronically.

Teachers will be transformed from dispensers of knowledge to facilitators of learning.

This fact in itself represents one of the most dramatic paradigm shifts ever imagined in terms of the curriculum of the future.

In order to ensure that the transformation of our education system occurs efficiently, we need strong, cooperative partnerships between educators and industry.

In particular, I want to stress our company's view that educators, in collaboration with parents and other stakeholders, must determine the shape, focus, and functionality of the classroom of the future.

Industry can create a group of educational tools. But educators and parents must determine how to adapt these tools to their particular local curriculum needs.

Of course, industry must play an important role in helping educators make informed decisions about how to use technology.

There are a host of new skills that educators will need if they're going to be effective in applying the new technologies in their classroom.

That's why TCI's created the J.C. Sparkman Center for Educational Technology. The Sparkman Center is a technologically advanced facility that provides hands-on training to help educators find solutions for the new learning environment, and it features a variety of technologies, both existing and emerging.

Educators who attend the center return to their communities with a better understanding of how they can integrate the tools more effectively.

Moreover, because the transformation to an information-based education system is complicated, we've developed a five point turnkey solution that we believe deserves some consideration.

This approach provides schools with a complete package of hardware, software, broadband network connections, teacher training, maintenance and support, on a leased basis for a fixed-cost per student per year.

This one-stop- shopping approach will simplify educators' efforts to retool schools with new technology.

If properly used, even over a short period of time, these new technology tools can produce dramatic results. One concrete example is provided by TCI's Showcase Schools Projects located across the nation.

In these projects, we've collaborated directly with faculty, parents and other stakeholders to design model programs. These schools operate as laboratories for educators across the country.

In Carrollton, Georgia, for example, TCI has established a fiber optic ring connecting all classrooms and homes, as well as the juvenile court system and all the social service agencies.

Six multimedia computers and extensive video networks were installed in every classroom.

Over the past four years, the results have been encouraging. Dropout rates in that school district have been reduced from 28 percent to five percent. Failure rates have been reduced dramatically.

As a result, the school has saved nearly a million dollars a year without raising an additional dollar in taxes.

Carrollton has substantial funds now that can be used to hire new teachers, upgrade special education classes, repaint classrooms, or use for a variety of other purposes.

The point is not always to raise new funds, but to redirect existing funds more efficiently.

TCI has constructed showcase schools in Oregon, Colorado, Texas, Missouri, Illinois, Indiana, Georgia, here in Washington, D.C., and Louisiana.

While technologies will do wonders to transform our education system, we must honestly acknowledge that this transformation is financially daunting.

No company or industry can do it for free. It's been estimated that $41.5 billion is required for the hardware, software, and infrastructure to transform our public schools to the information-based model.

Notwithstanding these costs, I believe industry and certainly the cable industry is committed to undertaking the transformation in a way that recognizes our obligations to the communities in which we live.

Educators have told us that they face three major obstacles in taking advantages of the new technology.

First, the initial capital cost to install the technology and the supportive networks is prohibitively high.

Second, technologies tended to become obsolete in relatively short period of time.

And third, technology expenditures tended to be unpredictable and therefore difficult to budget for.

As I mentioned, TCI's turnkey approach allows schools to lease a bundled package. Lease arrangements for an eight-year period at a fixed rate, and we address the hardware needs at certain intervals throughout the process.

In addition to these things, we would consider the networking portion of the school of the future, or the wide area network of the school of the future to be a connection to homes, as well.

And to that end, we're very willing and are encouraged to enter into revenue-sharing types of situations between schools and homes to further offset costs.

Finally, I want to address another complex issue. Ensuring that low income in rural areas share fully in the benefits of the new technologies.

We simply must find ways to apply educational technology in an egalitarian fashion, and we're committed to this goal.

We recognize that we don't have all the answers. That's why our showcase projects are operating around the country, but we're beginning to generate some real life experiences, and hopefully solutions will follow.

I hope my testimony today has been helpful.

We all have to work harder and more collaboratively in this area. However, we're very optimistic about the future, given the current state of technology.

Thank you.

[The prepared statement of Mr. Pat Wright follows:]

TESTIMONY OF

Pat Wright, Vice President
Educational Technologies
Tele-Communications, Inc.

Before the House Committees on Science and Economic and Educational Opportunities

October 12, 1995

Good morning, Mr. Chairmen and members of the Committees. My name is Pat Wright. I am Vice President of Educational Technologies for Tele-Communications, Inc. ("TCI"). As the name suggests, TCI is a diverse telecommunications company with interests in cable television, telephony, programming, and technology.

TCI is also a company committed to working closely with educators to breathe new life into our nation's education system through advanced communications technology and innovative approaches to learning. Our nation's elementary and secondary schools are facing enormously difficult challenges. Bringing about lasting change for the better will be a complicated process requiring difficult choices in the public and private sectors. But technology can and will make an important positive contribution.

Technology is evolving rapidly, with fundamental consequences for virtually all our nation's institutions, from business to medicine to education. This transformation is being

driven by the convergence of three critical developments: first, fiber optics, which has become the most cost-effective interactive broadband communications infrastructure; second, high-speed microprocessing, which allows virtually all kinds of digital processing at a very low cost; and third, operating system software that has evolved sufficiently to link distributed personal computers via high-capacity digital networks.

When coupled with the digitization of print, audio, and video, this technological convergence makes multimedia and interactive media more than just buzzwords. As a result, education, like every other business, is being transformed, and a new education paradigm is emerging.

TCI is committed to making education one of the first direct beneficiaries of this technological transformation.

TCI's interest in education actually began in 1989 when it took a leadership role in creating "Cable in the Classroom." Today, "Cable in the Classroom" provides 525 hours of educational programming per month free to 12 million students, 650,000 teachers, and 24,000 schools in TCI service areas.

Over the years, we heard frequent requests from educators for training in new communications technologies, help with installation and maintenance of networks, connectivity between

schools and broader communications systems, access to online services and databases, and access to advanced multimedia curricula.

We responded with high quality educational programming delivered through cable television lines to public and private schools located in TCI service areas throughout the country. For example, TCI has made available to a majority of the 65,000 schools and 60 million homes that currently have cable service an innovative 21st century learning tool called "What on Earth." "What on Earth" delivers selected news stories from around the world in a captivating multimedia presentation featuring photographs, text, video, sound, and graphics. The recipient of this year's EdNet "Rookie of the Year" Award, "What on Earth" is the first and only multimedia product delivered via digital cable-to-computer technology.

We have invested millions of dollars to bring cable to more than 90% of the schools located within our service areas. We built a unique and sophisticated training center to teach the teachers about state-of-the-art technologies and the many instructional applications that are available through the use of these new tools. We created model schools which will serve as national research and development centers in which educators, administrators, parents, and students can analyze the most effective applications of new technology in various curricular

areas. I will describe some of these initiatives in more detail in a few minutes.

In short, TCI believes that industry's commitment to education must go beyond providing more of today's programming or a simple hook-up to an existing distribution network. Such an approach is too simplistic. We must recognize that technological advances are beginning to transform our educational system from an industrial-based model to an information-based model.

The new, information-based model eliminates the barriers of time and location. In today's education system, students must be ready to learn when teachers are ready to teach. And they are limited to the classroom environment.

Technology unbinds the educational experience. Learning will take on a whole new look and feel. What we are likely to see is real-time presentation, on-line conferencing, and artificial intelligence that will allow students to access high quality, interactive multimedia resources on demand. Technology will allow students to access the expert when he or she is needed and work through virtually any course at their own speed. This is the 21st century version of the old Zen proverb, "When the mind is ready, a teacher appears."

Equally important, the technology will allow students to draw expertise from many sources simultaneously. Courses of the future will not be orchestrated by a single teacher or professor representing a single institution. Instead, they will combine the expertise of many teachers and other experts electronically. Teachers will be transformed from dispensers of knowledge to facilitators of learning This fact in itself represents one of the most dramatic paradigm shifts ever imagined in terms of the curriculum of the future.

These are some of my ideas about the classroom of tomorrow. I will provide further amplification of the role of technology in just a minute. But before doing that, I want to underscore something critical about the convergence of education and technology. In order to ensure that the transformation of our education system occurs efficiently, we need strong, cooperative partnerships between educators and industry.

In particular, I want to stress TCI's view that educators must determine the shape, focus, and functionality of the classroom of the future. Technology should not drive the education model. Technology is the enabler. Industry can create a group of educational "tools," but educators will have to determine how to adapt the tools to the particular curriculum needs of their local communities and educational institutions.

Of course, industry must play an important role in helping educators make informed decisions about how to use technology. There are a host of new skills educators will need to acquire if they are going to be effective in applying technology in their classrooms. Before teachers can clearly see a vision of how their classrooms will be affected, they have to understand what technology is available. It's difficult to do that when you are in a classroom that doesn't even have a telephone.

That is why TCI created the J.C. Sparkman Center for Educational Technology. The Sparkman Center is a technologically advanced facility that provides hands-on training to help educators find solutions for the new learning environment. The Center features cable-delivered resources and other technologies, including computer and CD-ROM applications, multimedia development, desktop video conferencing, video disc technology, and broadband connectivity to online data services and the Internet. Teacher training seminars typically last three days. In addition to providing an overview of the numerous forms of technology available for use in classrooms today, the Center provides all participants with a value-added package of software, manuals, and other teaching and reference materials. Educators who attend a seminar at the Center return to their communities with a better understanding of how they can integrate educational technologies into their daily teaching environments.

TCI is analyzing how to provide additional teacher training and support directly into local communities. We now make some Sparkman Center training services available via satellite to cable systems. We are exploring other ways to use our broadband networks to enhance teacher training. For example, we are considering using the networks to connect local schools with teacher colleges. The idea is to maximize our resources to provide learning when and where teachers need it.

Moreover, because the transformation to an information-based education system will be complicated, TCI has developed a 5-point "Educational Turnkey" solution. This approach provides school districts with a complete package of hardware, software, broadband network connections, teacher training, and maintenance support on a leased basis and for a fixed cost per student per year. We believe this "one-stop shopping" model will simplify educators' efforts to re-tool schools with new technology. Let me touch briefly on the five elements of TCI's turnkey education package:

1. **Local Area Networks.** TCI will create local area networks within each school building in a district to provide voice, video, and data connectivity within the school.

2. **Wide Area Networks**. Wide area networks will provide broadband connectivity throughout the school district, among the schools, homes, administrative offices, social services organizations, libraries, colleges, and other resources, such as the Internet.

3. **Hardware and Software**. TCI will provide state-of-the-art hardware and software appropriate for multimedia research and teaching. At least 4 to 6 computers can be installed per classroom.

4. **Teacher Training and Support**. In order to make the transformation from dispencers of knowledge to facilitators of learning, teachers will need to acquire a new skill set. TCI has made staff development a major component of its turnkey solution. As I mentioned earlier, TCI's Sparkman Center, as well as TCI's plans to use its broadband networks to provide teacher training directly into local communities, will offer instruction on how to effectively integrate technology into teaching, management, and administration.

5. **Network Maintenance**. On a national basis, TCI will support the installed turnkey networks from a central command location, using local support personnel where

appropriate. Using sophisticated software tools, TCI will be able to monitor the system down to the student's PC and to quickly correct any software and hardware problems.

TCI's turnkey approach is not simply a pilot project or marketing trial. It is a full-fledged commitment to a long-term partnership with educators.

Most importantly, by offering schools a packaged technology solution with a fixed-cost lease arrangement, TCI makes the transformation to the new education paradigm more affordable. I will address the issue of affordability in more detail below.

TCI's experience has demonstrated that if properly used, even over a short period of time, these new technology tools in turnkey school districts and elsewhere can produce dramatic positive results. One concrete example is provided by TCI's "Showcase Schools Project."

In this project, TCI collaborates with the principal and faculty to design model schools. These schools operate as laboratories for educators across the country to gain a greater awareness of how to use the new technology to enhance the learning process and to equip students with the skills needed to be productive in our competitive, global economy.

TCI's showcase schools include elementary, middle/junior high, and secondary schools located in the following rural, suburban, and inner-city areas:

1. West Linn, OR
2. Pueblo, CO
3. Dallas, TX
4. Columbia, MO
5. Chicago, IL
6. Evansville, IN
7. Carrollton, GA
8. Washington, DC
9. Baton Rouge, LA

In Carrollton, GA, for example, TCI established a fiber-optic ring around the entire school district connecting all classrooms and homes, the juvenile justice system, and the social service agencies. TCI also served as systems integrator in networking six multimedia computers and extensive video networks in every classroom. Further, TCI initiated the "Parenting Channel," which provides information to parents about various aspects of their children's development, including such things as nutrition guidelines and immunization requirements.

The results have been very encouraging. In Carrollton, GA, for example, the dropout rate decreased from 28 percent to 5 percent. Failure rates dropped significantly. Educators in Carrollton estimate that the reduced dropout and failure rates result in a savings of nearly $1 million per year. Without raising an additional dollar, Carrollton has substantial funds

that it can use to hire new teachers, upgrade special education classes, or repaint classrooms. The point is not always to raise new funds, but to redirect existing funds more efficiently.

Up until this point, I have focused on the tools educators and school systems may use to enhance the learning process. But the scope of the new education paradigm transcends the traditional classroom. It creates new opportunities and venues for individuals to use technology as an educational tool. A primary extension of the traditional classroom will be to the home. Soon, we will no longer ask the everyday question, "What's on television tonight?" Instead, the question will be "What do you want to be on television?" And the answer will be "Anything you want. Anytime you want it."

In survey after survey, TCI has found that education is at the top of consumers' lists of what they want in the next generation of television services.

Fortunately, TCI and the cable industry are uniquely suited to meet this need. Cable passes over 90% of American homes, and over 63% of American families subscribe to basic cable. TCI continues to work on the next step which is introducing interactivity and multimedia education applications into this well-penetrated broadband environment.

Interactive services in which customers alter the content of what they see on the screen are now being introduced in a number of cable systems. TCI is currently testing video conferencing technology over PCs using cable plant to extend computer networks from schools to children and parents in their homes.

These two-way connections between the home and the school have proven beneficial for teachers, students, and their families alike. They increase the flexibility of teachers' hours by allowing them to gain access from home, provide parents greater access to their children's teachers and schoolbooks, and enable students to learn at home when school is closed.

A key component to these and other home-based educational efforts will be the digital set-top box. This piece of equipment, located in the consumer's home, will contain sufficient power and memory to deliver multimedia educational services directly to consumers' TV sets. TCI has already ordered over one million digital set-top boxes which we expect to begin deploying in subscriber homes by next year.

Cable operators are also cur. `tly undertaking extensive trials with cable modem technology hich, among other things, will afford consumers access to the Internet and other on-line resources at speeds up to 1,000 times faster than what is possible using current dial-up telephone technology. I wish to

stress, however, that access to the Internet is not a panacea. The Internet is only one of the "tools" that may be used to create an effective education system. Moreover, educators, as well as parents, have expressed concerns about content on the Internet and have told us they do not necessarily want students to have unbridled access. It is not my purpose to resolve those issues here. I only point out that the issue is more complicated than simply hooking homes or schools up to the Internet.

The key is to provide educators with a smorgasbord of technology tools. In cooperation with industry, educators can select from this variety of tools to meet the unique educational goals of their local communities.

While the technology tools I have been discussing will do wonders to transform our education system, we must be honest in acknowledging that this transformation is a financially daunting prospect. No company or industry can do it for free. Rather, all participants must be creative in designing solutions to make this transformation affordable.

A recent survey of all 50 chief state school officers indicated that $31.5 billion is required for the hardware and software to transform our public schools to the information-based education model. Add another $10 billion for the

telecommunications infrastructure portion and the total cost to retool America's public schools is approximately $41.5 billion.

Notwithstanding these imposing costs, I believe industry, and certainly the cable industry, is committed to undertaking the transformation in a way that recognizes our obligations to the communities in which we live. We are prepared to be creative and to work hard to do this in a way that is affordable for schools. Government must do the same.

Educators have told us that they face three major financial hurdles in taking advantage of the new technology.

- First, the initial capital cost to install the new technology tools and the supporting networks has been prohibitive in many cases.
- Second, technology has tended to become obsolete over a relatively short period of time.
- Third, technology expenditures have tended to be unpredictable and therefore difficult to budget for. For example, many current infrastructure offerings are based on "metered use" which results in higher charges for greater use.

TCI has designed various approaches that address each of these issues. As I mentioned earlier, TCI's "turnkey" solution allows schools to enter into a lease with TCI for a bundled education solution. The lease arrangement is for an eight-year period at a fixed dollar amount per student per year. TCI will replace critical hardware and software every three to five years.

This approach answers each of the educators' primary concerns. The lease allows schools to avoid the large up-front capital costs of the network and associated equipment. The fixed cost component makes it easier for school districts to manage their budgets because they will know up front how much the system will cost. And the periodic replacement of critical hardware and software accommodates the rapid change of technology.

In short, by providing a bundled offering to schools at a fixed lease price, TCI's turnkey solution drives the price of educational technology down and the quality up. Educators have noted that it makes the wide-scale deployment of technology more affordable. Although it is too early to tell, I believe TCI's turnkey approach could reduce the overall price for school districts by as much as 20 percent.

TCI is convinced that metered access to these broadband networks makes no sense. Nor does it make sense to float a 20-

year bond issue to pay for something that has a practical lifespan of four to seven years.

TCI has devised other mechanisms to offset the costs for schools to make this technological transformation. The first one is our equipment giveaway program. In a turnkey school, when new equipment replaces the old leased equipment, TCI transfers ownership of the replaced equipment to the school at no additional cost.

In addition, TCI has explored potential revenue-sharing arrangements with schools. For example, TCI is considering sharing with schools a portion of the revenue it receives from sales of educational services directly into the home. These arrangements would create additional revenue streams for schools that could further offset the costs incurred to create broadbased educational networks. At a time when property taxes traditionally used to fund education are tapped out, such potential new revenue streams are particularly important. Again, public-private partnership is the key.

Of course, other mechanisms may exist to make this technology transformation affordable for all. For example, it may be appropriate to defray the subscription costs of interactive education as an element of job retraining programs. Also, it might make sense for government to provide incentives

for profit-making entities to engage in community infrastructure development, including education-related development. The main point is that we all need to think creatively about existing and new ways to fund the transformation to this new education model.

Finally, the affordability of this transformation, as well as the timing, will be impacted directly by the economics that exist in the industries that undertake the transformation. If the economics are favorable, the broadband networks and associated technology will be more affordable and available more quickly. If the economics are unfavorable, the transformation will be more costly and will be delayed. In this regard, it is critical that Congress pass and the President sign the pending telecommunications legislation. The legislation will create strong incentives for industry to step up investment in the infrastructure and equipment necessary to make educational reform a reality.

Before closing, I want to address another particularly complex issue that arises in connection with the convergence of technology and education -- ensuring that low-income and rural schools share fully in the benefits of the new technology. We simply must find ways to apply educational technology in an egalitarian fashion. TCI is firmly committed to this goal.

We recognize that we don't yet have all the answers. That's why TCI's Showcase School Project, which I described earlier, includes schools in rural and inner-city areas. We are beginning to generate some real-life experiences and, hopefully, solutions will follow.

There are reasons to be encouraged. Low-income and rural schools present an economic issue. How can we make technological transformation affordable in those areas? I discussed affordability earlier and offered several ideas for reducing the economic burden on rural and low-income school districts.

Moreover, our studies indicate that in low-income areas, cable television achieves very high penetration rates. So the vast majority of residents in these areas already have access to the broadband network, a critical element of the overall technology mix. Of course, residents in these areas will need certain equipment in their homes if they are to fully enjoy the new education paradigm. TCI's "turnkey" approach, which I described earlier, provides at least a partial solution. Under this approach, TCI will give the title of leased equipment to schools after four years with the understanding that the schools will migrate the equipment to homes in the community. I understand that other creative approaches are necessary, but we are making progress.

In considering rural areas, it is important that we not lock ourselves into any particular technological configuration. Communities and their school districts are not monolithic. We must be flexible enough to utilize all the technology tools that are available to us. For example, in rural areas, distribution of educational material directly by satellite, rather than cable, may be a more efficient solution. TCI believes that Primestar, a satellite distribution company owned by a consortium of cable operators, has great promise to upgrade the educational capabilities of rural schools.

As I have said, we all have more work to do in this area. However, if we can continue to have an honest, open dialogue, I am convinced that we can realize our common goals.

Finally, I want to note that, in terms of communications technology development, America is several years ahead of the rest of the world. This competitive business advantage can translate into an advantage in education as well. That, in turn, will sustain America's global leadership role for generations to come. If industry and educators continue to work in a creative and cooperative partnership, and if the government refrains from imposing restrictive economic regulations, I am convinced that we can achieve this worthy goal.

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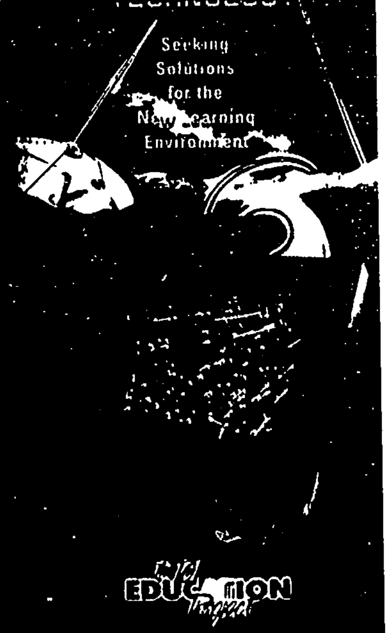
J.C. Sparkman Center For Educational Technology

303-267-6700

1-800-267-2527



Sparkman Center – An Overview

As we approach the 21st Century, it is becoming increasingly obvious that technology will play a vital role in reshaping the way we work, entertain, and especially the way we educate ourselves and our children. With technology tools becoming more available and affordable, time and distance will no longer be factors in the way instruction is delivered. Education will be personalized and accessible to students regardless of where they happen to be located.

The J.C. Sparkman Center for Educational Technology is a technologically advanced facility established to help educators find solutions for the new learning environment. It is open to all educators, school board members, administrative and district personnel, parents, and others for hands on training.

The Center features cable delivered resources and a variety of technologies including computer and CD ROM applications, information access, multimedia development, desktop video conferencing, and video disc technology. The Sparkman Center also utilizes other emerging educational technologies including broadband connections to online data services through the Internet.

The facility features

- One 24 Macintosh classroom
- One 18 PC classroom
- Laser discs
- QuickTake Cameras
- VCRs
- TVs
- Color Scanners
- Laser Printers
- Color Style and Laser Writers
- Various multimedia and educational software

Companies contributing products and resources to the Center include

- Apple Computer, Inc
- Compaq
- Gold Disk, Inc
- Houghton Mifflin
- Ingenius
- International Society of Technology in Education
- Libraries Unlimited
- The Cobb Group
- The Lightspan Partnership Inc
- Tom Snyder Productions, Inc
- Microsoft
- MultiMedia Schools
- Multimedia Design Corporation
- SUN Microsystems
- Wentworth World Wide Media

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Introduction & Overview of the TCI Education Project

Why is TCI providing a Center for Educational Technology?

As a leader in the [illegible] of the nation's information super highway, TCI [illegible] responsibility to assist the [illegible] especially the [illegible] community [illegible] understanding how these new [illegible] learning.

Who can attend the programs that are offered at the Center?

[illegible] school board [illegible] administration [illegible] personnel, parents [illegible]

Where is the Center located?

[illegible]

When is the Center open?

The Sparkman Center is open Monday through Friday. Special training needs will be accommodated when needed.

What kind of training does the Center offer?

The Center offers a wide variety of opportunities in which participants will learn about state of the art technologies and the many instructional applications that are available through use of these new tools.

Do you broadcast via satellite any training?

Yes. Some teacher inservices are made available via satellite to all TCI systems as well as other cable operators who [illegible] to carry them. To find out when the next teacher inservice [illegible]

How much does the training cost?

Effective Fall 1995, the cost of three days of training will be $7,400. This price includes airfare, hotel, all meals and ground transportation. A $1,700 package is also available. This second package includes only the cost of training. Participants who select this low cost option will be responsible for their own travel arrangements, lodging, meals and other expenses.

All participants will take with them a value added package consisting of software, manuals and other teaching and reference materials.

In conjunction with TCI's Education Project, the Sparkman Center will also offer the following classes at no cost: Cable in the Classroom, media literacy, critical viewing skills, repurposing of video, XChange, and What on Earth.

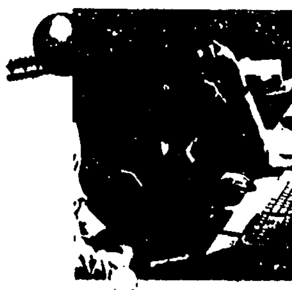
For additional information about the above classes, call (303) 267-6700.

Does the Center award scholarships or grants?

The Sparkman Center does not award scholarships or grants.

However, each fall, TCI initiates a nationwide acquisition campaign. The money raised through this campaign is used by our systems to either purchase equipment for local schools or send teachers to the Sparkman Center.

To be eligible for these fall grants, the school in which you teach must be located within a TCI service area. Contact your local TCI office for more information.



The TCI Education Project (TEP) is proudly sponsored by Tele-Communications, Inc., the nation's largest cable operator and its affiliate companies.

Although education primarily involves teachers, books, and classroom work, there is a supplementary role television can play in many instances. Therefore, TCI has made a firm commitment to education. To demonstrate this commitment, the company has invested several million dollars to cable more than 90% of the schools located within its service areas. To date, over 16,000 schools have been cabled, reaching over 450,000 teachers and 8 million students.

TEP provides high quality educational programming and data services through cable television lines to public and private schools located in TCI service areas throughout the country. Schools are not charged for the cost of the programming or cable installation to one central location.

Each school located within a TCI service area is eligible to receive the following free of charge:

1. A cable drop to one central location for access to programming and data services.
2. Two XChange kits (Mac or PC format) which include all appropriate electronic hardware and software to connect the school's computers to this exciting data service.
3. In addition, schools will receive *Cable in the Classroom*, a monthly programming guide published 11 times a year. This guide covers program offerings and also provides interesting case studies and overviews of teachers who are making effective use of cable programming and data services in a variety of curricular areas and grade levels.

Ingenius

As part of the TCI Education Project, schools are provided the necessary equipment and software to connect to the XChange [illegible] from [illegible] (formerly X•PRESS Information Services) free of charge.

XChange is a 21st century learning tool that brings the world to the classroom. In addition to providing information that can connect curriculum and instruction to the real world, XChange also helps students acquire important skills necessary to succeed in the information [illegible]

Technology & Teaching
Solutions for the 21st Century Classroom

Registration Form

...is effectively gathering, processing and communicating information.

XChange delivers the latest national and international news as well as weather data, stock reports, and a variety of other information pertaining to education and business. Many Cable in the Classroom support materials are available through XChange.

Also available from Ingenius is What On Earth. What on Earth (WOE) is the world's first cable delivered multimedia learning resource for schools and homes. Each weekday, WOE digitally delivers six selected news stories from around the world in a captivating multimedia presentation featuring photographs, text, video, sound and graphics. The first and only multimedia product delivered via digital cable to computer technology, WOE will be available to a majority of the 65,000 schools and 60 million homes that currently have cable service.

Teachers interested in getting more information can call Ingenius toll free 1 800 7PC NEWS or contact via the Internet ...

Cable in the Classroom

TCI is proud to have been a founding member of Cable in the Classroom, a consortium of cable programmers and operators dedicated to the creative and innovative use of quality cable programming in the classroom.

As a member of Cable in the Classroom, TCI and the many programmers believe cable resources can have a substantial and valuable impact on education by encouraging the development and delivery of programs, data, and software that inform, educate and inspire.

Over 525 hours of educational programming is produced each month for schools. This 525 hour block is produced without advertising and with lenient copyright restrictions, meaning programming can be taped and used at the discretion of educators.

The programs offered cover a wide-range of topics and have been selected based on their academic merit. Programming is available for a variety of age levels and abilities ranging from pre school to post secondary.

Many programs have teacher support materials available that provide useful lesson plans and activities related to the topics covered. These materials are designed to facilitate critical thinking, class discussion and suggest a variety of designed activities to actively engage students in the learning process.

This three day seminar is designed to give participants an overview of the numerous forms of technology available for use in classrooms today. Participants will also receive hands-on experience using these technologies and learn strategies for implementation.

Participants will return to their communities with a better understanding of how they can integrate educational technologies into their daily teaching environments. All participants will take with them a value-added package consisting of software, manuals, and other teaching and reference materials.

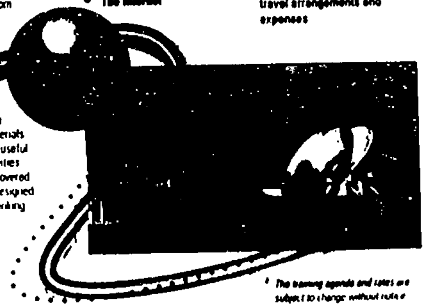
Topics of Training:*

- Distance Learning
- Computer and Video Networks
- On-Line Services
- The Internet
- Bulletin Board Service (BBS)
- Cable and Satellite Delivered Resources
- XChange
- What on Earth
- Multimedia in Education
- CD ROM
- Video Disc
- Tour of TCI's National Digital Television Center

Options and rates:*

Option A: $2,400 - includes three days of training, materials, airfare, ground transportation, meals, hotel, and other expenses.

Option B: $1,200 - includes three days of training and materials. Participants selecting this option are responsible for their own travel arrangements and expenses.



* The training agenda and rates are subject to change without notice.

Call (303)267-6700 for a schedule of training.

Return this Registration Form to:
"The Convergence of Technology and Teaching"
The J. C. Sparkman Center for Educational Technology
4100 E. Dry Creek Road, Littleton, CO 80122

☐ **Please register me for Option A- $2,400**
☐ **Please register me for Option B- $1,200**
(Pre-payment is required)

1 Name (please print) ______
2 Home Address ______
3 City ______ State ____ Zip ______
4 Daytime Phone (____) ______
5 Evening Phone (____) ______
6 Is your School or a local Business sponsoring your visit to the Center?
☐ Yes ☐ No If no, skip to line 13
7 Sponsoring School or Company ______
8 Sponsoring School or Company Street Address ______
9 Sponsoring School or Company City, State and Zip ______
10 Sponsoring School or Company
11 Phone (____) ______
12 Fax (____) ______
13 Computer Platform Preferred ☐ Mac ☐ Windows
14 How many years have you used a computer? ______

☐ Payment Enclosed* ☐ Bill me ☐ Bill my company/school

Charge my:
☐ American Express ☐ Master Card ☐ Visa

Card # ______

Expiration Date
Month ______ Year ______

Signature ______

Print Name as shown on card ______

☐ If your credit card billing address is different from the address above, please check here.
*Make check or money order payable to: The J. C. Sparkman Center

Call (303)267-6700 for a schedule of training

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How to Register

This Section to be completed by TCI Corporate and System Offices Only

8158 0007

Fax back to

or mail to

By Mail Return this form to
TCI The J.C. Sparkman Center for Educational Technology
4100 E. Dry Creek Road, Littleton, CO 80122
Attention: Registration

By Phone (303) 267 6700

By Fax (303) 267 6720

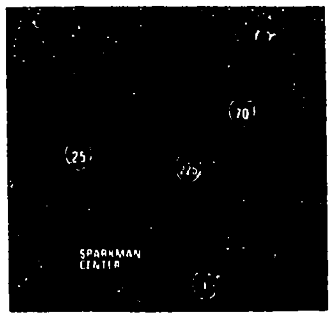
Hotel Reservations

If you are making your own hotel reservations, here is a list of recommended hotels that are located near the Center

Denver Hilton South (303)779 6161
Hampton Inn Southeast (303)792 9999
Marriott DTC (303)779 1100
Marriott Residence Inn (303)740 7177
Radisson Hotel Denver South (800)477 4900
Days Inn (303)721 1144
Motel 6 (303) 790 8220
Woodfield Suites (800) 338 0008

The Sparkman Center's Refund Policy

The Sparkman Center will give you a complete refund if you cancel up to two weeks before your training begins. Please note however that cancellations received less than two weeks before the seminar are subject to a $150 service charge. In fairness to all attendees confirmed participants who do not attend their scheduled session are liable for the entire fee unless they let us know in advance.



Mr. J.C. Spark...
Former Exec...
Vice Pres...
Executive...
Tele Com...

The TCI EDUCATION Project

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Section I-TCI Educational Turnkey Solutions

Introduction

TCI Educational Technologies, Inc. was created to take advantage of the existing broadband cable network that exists in communities around the country that consists of schools, district offices, and the homes of school children. This broadband network is currently in place and able to be expanded to provide a network of video, voice, and data communications within the school system community. This network, combined with the educational experience that TCI has gained through the various educational projects defined in the previous section, places TCI in the unique position of being able to assist Educators with their technology plans.

TCI feels strongly that the need in this area goes well beyond the communications networks that will be established that will tie the schools and district offices together with their students, parents, and the outside world. The need extends to the hardware required to make the networks operate and to the vital element of staff development to ensure that all user have the knowledge to effectively use the network systems. It also includes the support required to keep the hardware and networks up and running. This combination of services provides the elements of the "turnkey" solution that TCI is proposing. Specifically, the TCI Educational Turnkey Technology Solution consists of the following:

- Wide Area Networks
- Local Area Networks
- School/Home Connection
- Hardware (Computers, TVs, VCRs, Set-Top Box)
- Staff Development
- Hardware and Network Support

School Districts have generally identified three reasons why it has been difficult for them to implement this type of technology plan on their own in the past.

1 The initial capital cost to install this magnitude of a system has been prohibitive in many cases. The solution for this element that is part of this proposal is for the turnkey solution to be paid for over an eight year period at a fixed dollar amount per student per year.

2 Technology has tended to become obsolete over a relative short period of time. The solution to this problem is to plan for that obsolescence in advance. The plan in this proposal is to replace the computer hardware after the fourth year.

3. Technology expenditures have tended to be unpredictable into the future and therefore difficult to budget for. This proposal will show a fixed cost per student over the eight year period of the contract.

The remainder of this section will go into the elements of the turnkey solution in more detail.

Wide Area Networks

The primary building block of the Educational technology plan is the wide area network. It will support both the administrative and instructional applications within the district. Without this piece, it would be difficult, if not impossible, to have centralized systems such as student records or district wide video staff development. With the wide area network in place, the other elements of the turnkey solution will have a foundation from which to build upon. The wide area network will provide broadband connectivity throughout the school district, to the homes, to community services such as public libraries and higher education, and will access multiple resources such as the Internet.

The wide area network can be broken down into three components depending on the type of transmission on the network. These are:

- Data
- Voice
- Video

Data Networks

As the name implies, the data networks will handle the data transmission on the wide area network. The applications that characterize this type of data movement the best on the wide area network will be the administrative system applications such as student information that is needed at the district level, but is input at the school level. It also includes such applications as the business areas of e-mail, and document sharing using a word processor. The connections to the school library and to all the libraries in the district as well as the public libraries will be predominately data communications. Looking at these applications would suggest that a high speed, broadband connection would not be required with data communications and that would only be required with video delivery. That is certainly not the case with some of the newer applications that have been emerging in education using data networks. Examples are the proliferation of multi-media (graphics and sound) applications that will be using the data networks when accessing the Internet or using desktop video conferencing. These applications, while showing video, are actually data networking applications that need the broadband capacity that the cable structure can provide.

Voice Networks

The voice networks are the most familiar to us as they are characterized by the plain old telephone system we have all grown up with. Some interesting applications are starting to emerge in education using this voice network. It starts with putting a telephone in every classroom and by giving each teacher a voice mailbox. The teacher can now begin to do such things as ask questions during a video staff training session that is being shown in the classroom during a planning period or responding to a distance learning class that is one way video and two way audio. The teacher will also have better access to the home. In addition, since the voice is part of the wide area network, opportunities exist for more telephone lines and such things as four digit dialing within the district.

Video Networks

Perhaps the most exciting piece of the wide area network is what the video component brings to the educational process. This will include such applications as distance learning, course sharing within the district, staff development, use of the programming that make up the Cable In The Classroom, a local area access channel which can deliver video content to the homes, security, and on and on. This can be set up as one way or two way video depending on the use. Using the wide area network, the video can originate anywhere in the district or beyond and be shown to any school in the district. When we discuss the local area network piece next, it will be obvious that video can originate in any classroom in the district and be shown in any other classroom or classrooms in the district.

Local Area Networks

Local area networks will be created within the school buildings to provide similar capabilities that the wide area networks have provided between buildings. That is, the local area networks will provide connectivity within the school. This will allow all computers within the building to be tied to each other and then through the wide area network to be tied to all computers within the district. In addition to computers, the local area network will provide for other end devices such as TVs and telephones because, like the wide area network, data, voice, and video capability will be networked throughout the buildings. Some of the applications that the local area networks will make possible are:

- Access to all computer applications in the building to all computers. This will include library catalogs as well as electronic reference materials. It will also eliminate, to a large degree, the use of floppy disks as the programs can be stored on a central file server.
- Student grades, attendance, and record keeping will be streamlined because the data will be captured at the source and networked to the appropriate computer file.
- The various video applications can originate in any classroom or be shown in any classroom using the local area network wiring. By using the wide area network, this same video can be shown in any district location, homes, and when connected to the cable network, can be shown anywhere in the world.
- E-mail will be possible within the building and within the district and beyond.
- Broadband access to the Internet will be available to all computers on the local area networks.

Both the wide and local area networks form the basis of any educational technology plan because they provide the foundation of connectivity within the district that all applications can build upon. They are key for both the instructional and administrative applications. On the instructional side, they bring the distance learning video as well as the high speed access to the various resource information within the library and the Internet. On the administrative side, they allow the data to be captured once at the source such as attendance and used by the entire district. The networks also provide for significant efficiencies within the district. Examples are the reduction of redundant operations as well as the elimination of both teacher and student movement in such areas as staff development and library access

School/Home Connection

Research has shown that there are three important questions that parents continually ask and seldom get answers to

1. What did my child do in school today?
2. What are the homework assignments?
3. How can I help?

The answers to these questions and many more can be provided through a number of ways. First, the telephone can be used by utilizing voice mail. There must be enough lines and access to telephones in the schools to make this a reality. Next, the home computer can be used with such applications as e-mail. Finally, the TV can be used in the home with the addition of a more powerful set-top box.

The future of educational technology suggests that these applications will only be the beginning of the important school/home connection. The next several years will bring the need for high speed, broadband connectivity to the home for such applications as access to multi-media reference material, courseware for classes missed, and independent study for extra classes and credit. TCI is ideally positioned for this new wave of high speed connection between the school and home. The existing cable structure passes 90+ percent of all homes and currently 63 percent of all homes subscribe to basic cable. The basic level of service between the home and school will be the telephone with the TV and computer taking on an expanding role as the applications begin to tie the home closer to the school. Video takes on a larger role as the ability to communicate directly from any point in the district to all homes in the district becomes feasible using the school networks tied to the existing cable network.

Hardware

The hardware devices in the TCI Educational Turnkey Solution will be items such as computers, cameras, telephones, TVs, VCRs, and set-top boxes for the home. The reason that hardware is part of the turnkey solution is because of the need to closely match the hardware to the applications that will run on the networks. In addition, the turnkey philosophy is that hardware should be leased and not owned and that replacement should be planned into the solution which will create a predictable pricing model over a number of years. Other key issues relative to hardware include:

Critical Mass Of Hardware - It is important when designing the network that there is enough hardware in all locations so that the applications will work effectively. An example of this not being the case is when trying to implement an e-mail system when teachers or administration do not have access to computers or there is not enough outside line capacity. It just doesn't work. The first step is to thoroughly understand the applications desired before defining hardware.

Plan For Replacement - Hardware technology is changing rapidly. With the current move toward multi-media applications in education, it is easy to see why it is important to stay up with and hopefully ahead of the technology curve. But you can't always stay up with the curve. Therefore, the turnkey solution provides for periodic replacement of critical hardware. This suggests that the hardware is leased with replacement every three to five years depending on the application. The replaced hardware will then be owned by the district and can be used in less advanced applications. This plan for replacement is built into the turnkey solution and is priced on a fixed amount per student per year.

Hardware Preference Is District Choice - The networks will be designed in most cases to support both Apple and PC based systems. It is not the intention of the turnkey solution to dictate hardware, but rather propose the appropriate hardware power requirements for each application. The proposal will contain a "Good", "Better", and "Best" configuration and the applications where each may be appropriate. The following chart shows these different configurations:

Computer Configurations

	GOOD	BETTER	BEST
APPLE			
Make/Model	Macintosh LC580	Power Mac 5200/75 LC AV	Power Mac 7100/80 AV
Processor	66/33 MHz 68LC040	75 MHz Power PC 603	80 MHz PowerPC 601
PC			
Processor	486 DX2/66 MHz	Pentium 60 MHz	Pentium 100 MHz
APPLE & PC			
RAM	8 MB	8 MB	16 MB
Hard Drive	500 MB	500 MB	750 MB
CD-ROM	No	Yes	Yes
Video In/Out	No	Yes	Yes
Ethernet Card	Yes	Yes	Yes
Sound Card	No	Yes	Yes
Speakers	No	Yes	Yes

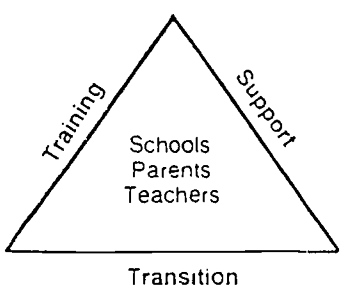
Staff Development

Staff development is critical to the successful implementation of any technology plan, particularly the TCI Turnkey Solution. A major component of the Turnkey Solution is staff development, which provides the knowledge to effectively integrate technology into instruction, management, and administration.

The role of the Sparkman Center is to provide support and enhance staff development. The unique technological capabilities of the Center allow it to deliver staff development without the traditional boundaries of time, distance and location. The staff of the Sparkman Center includes educators whose combined experience totals over eight decades of training experience. The center will assist in creating and providing solutions for the new learning environment.

The Sparkman Center philosophy for staff development is based on the following beliefs:

- Staff development is based on developmental learning stages designed to meet the needs of the novice to the proficient user.
- Training should focus on the integration of educational technology into the curriculum which will optimize the teacher/student ratio.
- Technology is an evolutionary process. It is a continuous and exciting journey.
- Staff development empowers teachers to take responsiblity for their own education
- Development supports must be both practical and pedagogical.



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The following limitations exist for effective staff development: (1) The industrial age model school still shapes our current teaching practices; (2) Since teachers are the gatekeepers, students use of technology is limited by their teachers' lack of staff development; (3) Staff development needs to address our cultural beliefs about what are "real schools."

Staff development is a high priority of the "turnkey solution" and helps to address many of these limitations. As a result of on-going staff development through TCI's Turnkey Solution, teachers will be able to meet the needs and demands of the 21st Century classroom.

Support

The support aspect of the TCI Turnkey Solution refers to the support of the networks and the hardware. With the sophistication of today's technology, it would be difficult for a school district to assume full support responsibility for the elements of this turnkey solution. This support can range on the front end of the project from opening the computer box, setting up the computer, and testing it on the network. On an ongoing basis, the support will be the maintenance of both the hardware and network to assure the availability of each.

On a national basis, TCI Educational Technologies, Inc. will be in a position to support the installed networks and hardware from a central command location similar to the current TCI network that is supported from Denver. This network, consisting of over 500 locations from Puerto Rico to Hawaii, is monitored around the clock and if a problem develops, the people in Denver can actually take control of a specific computer on the network and determine what the problem is, whether they can fix it, and if not, call for local support.

The turnkey solution is intended to provide this full support. For each individual district, some of this support effort may be performed by the district if they are in a position to do so. Each proposal will contain the results of this type of discussion with the district and a custom approach defined if the district wants to take on some of this role.

TCI Educational Technologies, Inc.

CREATING SOLUTIONS FOR THE NEW LEARNING ENVIRONMENT

Educational Turnkey Technology Solutions

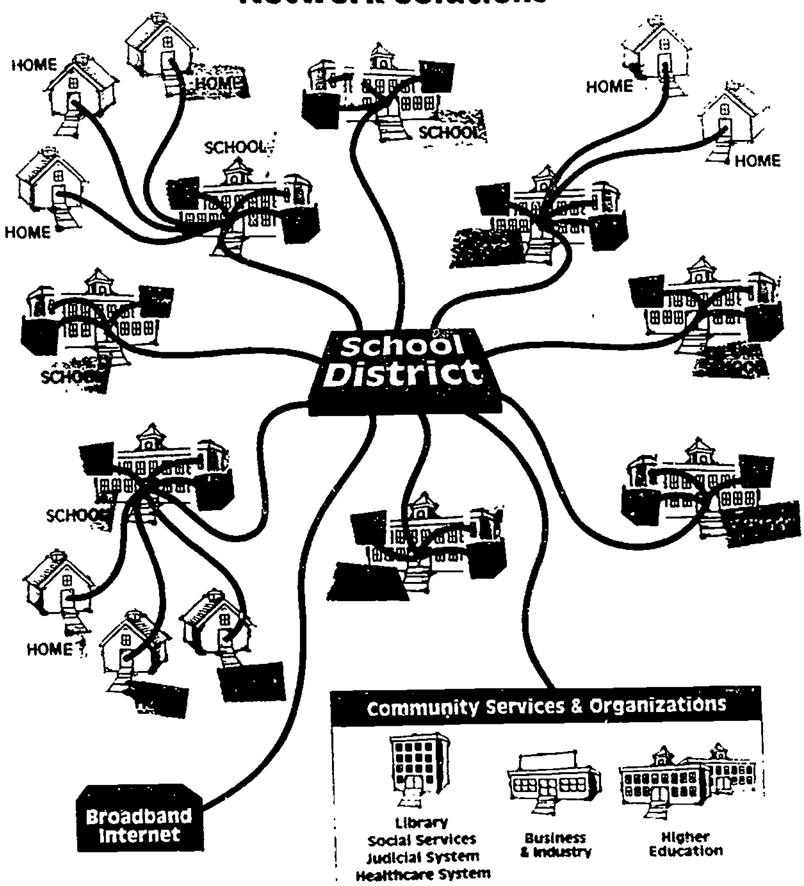
- Wide Area Networks
- Local Area Networks
- School/Home Connection
- Broadband Internet Connection
- Hardware (Computers, TVs, VCRs)
- Staff Development
- Hardware and Network Support

For additional information, contact
Pat Wright, Vice President
TCI Educational Technologies, Inc
(303) 267-4751

TCI Educational Technologies, Inc.

CREATING SOLUTIONS FOR THE NEW LEARNING ENVIRONMENT

Network Solutions



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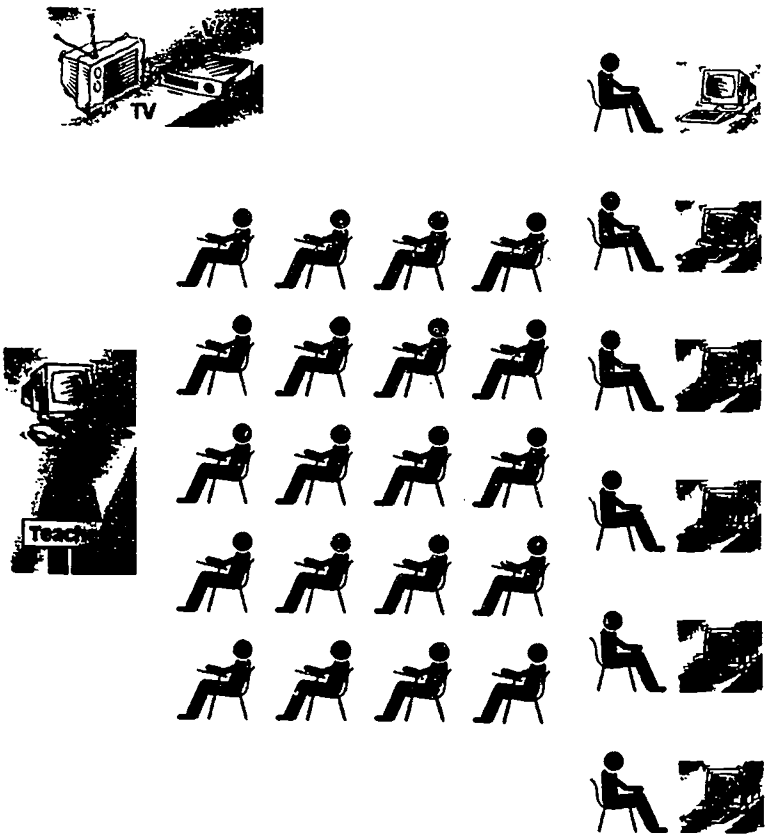
TCI Educational Technologies, Inc.

CREATING SOLUTIONS FOR THE NEW LEARNING ENVIRONMENT

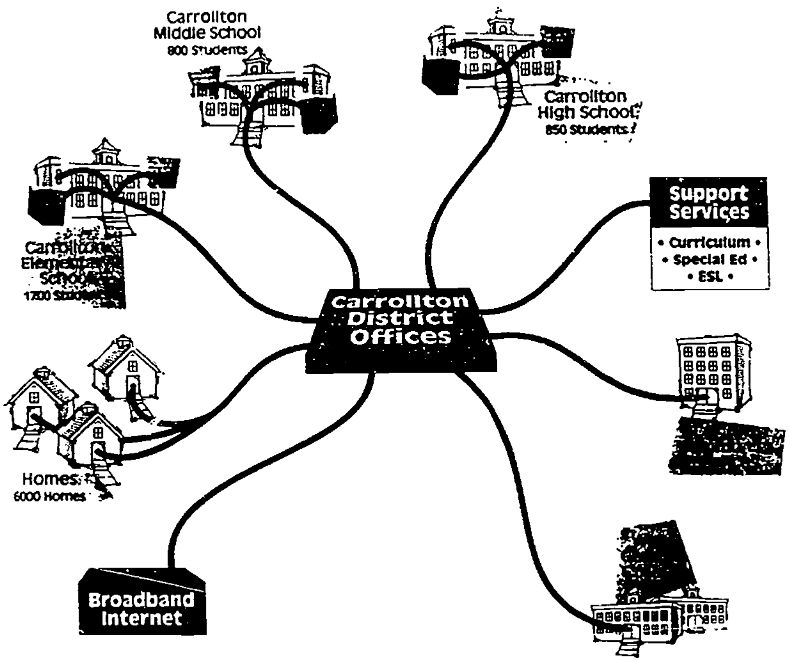
Classroom Solutions



TCI Educational Technologies, Inc.

CREATING SOLUTIONS FOR THE NEW LEARNING ENVIRONMENT

Carrollton, Georgia



Voice, Video & Data Throughout District

- 1 Computer for every 3 students •
- Telephone in every classroom •
- TV/VCR in every classroom •
- Video in/out every classroom •

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The TCI EDUCATION Project

TCI Showcase/Laboratory Projects

The TCI Showcase/Laboratory School program was initiated in the fall of 1990, barely one year after the *TCI Education Project* was launched in 1989. The primary objective of a showcase school is to develop a working laboratory. This allows for experimentation and analysis of the high-quality cable programming and data services offered through the *TCI Education Project*.

Through this program, TCI works in collaboration with the principal and faculty in the design of a showcase school. The first step in the process is to provide a thorough overview of all resources available to a school. Following this initial awareness training, each teacher has the opportunity for input as to how the resources can best be applied in his/her classroom for a 21st century learning environment. Because of input from these educators, each TCI showcase school is unique in addressing the particular educational needs of its community and student body.

Through this design process, each classroom is appropriately equipped with the tools necessary to effectively integrate the programming and data services into the delivery system for insuruction. Some of these items are permanently installed in each classroom, others are made available through computer access from at a central location within the school. This central location could be the media center or library.

Resources that are part of various Showcase/Laboratory sites:

- Television monitors
- Video cassette recorders
- Personal computers (IBM or Macintosh)
- Closed circuit video channels
- Laser disc technology
- Multi-media hardware and software
- Video distribution systems
- CD-ROM technology

As stated, the primary objective of a showcase site is to facilitate experimentation and dialogue among the faculty in an attempt to discover effective cross-curricular applications of the resources provided.

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During this process, it is important to work closely with educators in addressing issues that may arise, such as: the level of support required by teachers to effectively use the tools and resources supplied, how best to organize for instruction, how the role of the teacher is affected by new classroom tools, student participation in the learning process, and the types and amount of staff development required.

A second objective is to share with others the products and process involved in developing a showcase site. By allowing fellow educators to visit these schools while they are in session, greater awareness is gained of what can be done to equip students with the skills necessary to be productive in a competitive, global economy. Educators can also observe first hand how the school functions differently as a result of this initiative. Since educators are the architects of the project, a high level of credibility exists for replication of the strategies which are found to be most effective.

Eight showcase projects have been or are being developed, at the following sites:

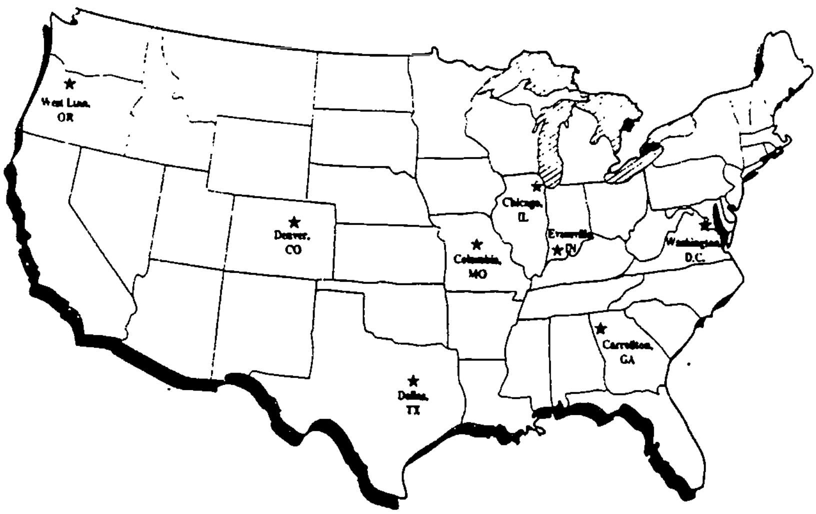
- Carrollton High School in Carrollton, Georgia
- West Linn High School in West Linn, Oregon
- W. Bruce Evans Junior High School in Washington, D.C.
- Bryan Adams High School in Dallas, Texas
- Stephen K. Hayt Elementary School in Chicago, IL
- The Evansville Signature High School in Evansville, IN
- Cedar Ridge Elementary School in Columbia, MO
- National Teacher Training Facility in Denver, CO

TCI's commitment in the showcase school project is to develop sites in a variety of communities (rural, small-town, suburban, urban and inner city) across the country and at each level of education (elementary, middle/junior high, and secondary). This allows for a true cross-section of America to be included in this effort.

Currently 14,000 schools are participating in the *TCI Education Project*. TCI believes that what is learned in the pioneering efforts of these showcase/laboratory sites will help educators everywhere improve the overall quality of American education.

The TCI EDUCATION Project

TCI Showcase/Laboratory Projects



These sites will serve as national research and development centers in which educators, administrators, parents and students will decide the most effective applications of cable resources in the various curricular areas.

For more information, see back page.

TCI - We're Taking Television Into Tomorrow

TCI Showcase/Laboratory Projects

Locations & Contacts

1

Carrollton High School
202 Trojan Drive
Carrollton, GA 30117

Contact *Robert Hendrick*
Director of Technology
(404) 834-1568

2

West Linn High School
5464 West A Street
West Linn, OR 97068

Contact *Clark Irwin*
Principal
(503) 656-2618

3

W. Bruce Evans Junior High School
5600 East Capitol Street, NE
Washington, DC 20019

Contact *Zorv Z. Kenon, II*
Principal
(202) 724-4727

4

Bryan Adams High School
2101 Millmar Drive
Dallas, TX 75228

Contact *Linda Garrett*
Media Specialist
(214) 319-0140

5

Stephen K. Hayt Elementary School
1518 West Granville Avenue
Chicago, IL 60660

Contact *Donald J. Hill*
Principal
(312) 534-2040

6

The Evansville Signature High School
c/o Evansville/Vanderburgh School Corporation
Administration Building, One S.E. 9th Street
Evansville, IN 47708

Contact: *Dr. Phillip Schoffstall*
Superintendent
Mike Russ
Director of Technology
(812) 465-8546

7

Cedar Ridge Elementary School
1100 Roseta Avenue
Columbia, MO 65201

Contact *Donna Dodge*
Principal
(314) 886-2324

8

National Teacher Training Facility
c/o Tele-Communications, Inc
Post Office Box 5630
Denver, CO 80217

Contact *Pat Wright*
Director of Educational Services
(303) 267-4736

Chairman WALKER. Thank you, Mr. Wright.
Mr. Mendenhall.

STATEMENT OF MR. ROBERT W. MENDENHALL, GENERAL MANAGER, K-12 EDUCATION, INTERNATIONAL BUSINESS MACHINES CORPORATION

Mr. MENDENHALL. Thank you, Mr. Chairman.

I was happy to hear, as we began this morning, that this Committee is not only about technology but about education because I think we need to focus on education as opposed to the technology.

I've been involved in educational technology for 20 years, and currently oversee IBM's K-12 education business, and yet I have to say that we are in general wasting the money in our schools that we're spending on technology.

And the reason for that is that it is not a matter of infrastructure, and our focus has been on technology infrastructure. We spend on computers and wiring and hooking things up, and then there are three more studies written that say computers are in classrooms and don't make a difference, because we're going about it the wrong way.

Most technology plans in our country focus on getting one computer for every five or six children, or on getting wired, as opposed to focusing on the outcomes, the results that we hope to achieve from the technology.

At the same time we set aside 25 or 30 percent of the technology money to train teachers, but that training is more focused on making them computer experts than it is on making them better teachers through the use of technology.

There's an idea by some, as we look into the future, that talks about access for all, computers for everyone, all content available, incidentally for free on the network, and somehow this revolution in technology will sweep away schools and provide for learning any time, anywhere.

My view is that that's an unrealistic vision of the future, not because the technology won't be there or allow us to do it, but for a couple of other significant reasons.

First of all, the technology won't be everywhere, at least for 20 years.

It will not be in the homes of the very poor in our country and that's the population that's growing.

If it is in those homes, it won't be used because of what Mr. Goodling said earlier about dysfunctional families. Those kids don't go home except to sleep and sometimes not even to sleep.

They don't have parents to work with them on computer applications, and schools become therefore our last resort for access and for equity, for a larger and larger percentage of our children.

Even with access, a lot of the best content won't be free. And as we focus on getting access for everyone, we have to recognize that the best content will be created by private enterprise and will be created with a profit in mind.

The real problem is that this great infrastructure will be created largely into homes by the entertainment industry, just as tv was. And I think we face the same challenge in entertainment versus education on the new network.

As Dr. Kay said earlier, the content exists today in books, in libraries, even educational tv, but our children are not availing themselves, I mean, they do not choose to watch educational tv. Those are not in the top ten programs. They are not accessing information in books, and yet we somehow believe that by putting it on line, they will all desire to do that, as opposed to play games or chat across the network.

We do need radical reform, but we still need schools. In fact, I think we have no choice but to improve our nation's schools.

And I will also say that I think technology is the only option for real change in education.

The reason we have to change is the amount of information in the world will double four times by the time my daughter in kindergarten graduates from high school. So the old model of a teacher standing in front of a classroom delivering content, the knowledge that you're supposed to know, is outdated.

Education has to change to teach our children how to access information, how to find information, how to acquire it, apply it, use it.

And in order to do that, we're going to have to retrain the work force, which are the teachers in this country. And it will require a substantial investment to do that.

By the way, computers are cost-effective in the classroom. You need approximately a computer for 20 percent of the kids in the classroom. You need equal funding, however, for applications and training. That amounts to three to five percent of the school budget on an on-going basis. Technology is not a one-time event.

But for that, we have proven time and time again that we can get 20 percent learning improvement. I'll say that again, 20 percent learning improvement for three to four percent of the school budget.

Now that's on standardized tests because that's our best measure today, but perhaps we have even more learning improvement if we had better tests.

Therefore, my recommendations are the following. Number one, we need to direct more funding to technology. Even as we cut educational funding, we can nevertheless direct more of it to technology as opposed to using it to support the status quo in our schools.

Number two, for that which we spend on technology for every dollar spent on infrastructure, we should match it with a dollar spent on the applications and the training to make that infrastructure meaningful in our schools.

Number three, we must tie the funding to actual outcomes, to the results we expect in improved learning, to keep it from being wasted.

And number four, we do need affordable access in schools and libraries across this country because that is where the lower portion of our population in particular will get their access and get their education.

Thank you very much.

[The prepared statement of Mr. Robert W. Mendenhall follows:]

Statement of

Mr. Robert W. Mendenhall

General Manager - K - 12 Education

International Business Machines Corporation

on

Educational Technology in the 21st Century

before the

Committee on Science

and the

Committee on Economic and Educational Opportunities

Congressional Hearing

United States House of Representatives

October 12, 1995
Washington, DC

Good morning, Mr. Chairman -- Mr. Walker and Mr.Goodling, and members of the Committees. There is no subject more important to the the health of our nation -- than the education of our children.

I am Robert W. Mendenhall, and I have been involved in educational technology, in various companies, for almost 20 years. Today I am here to speak with you as General Manager of IBM's K-12 Education business. My company provides hardware, software and services for both administrative and instructional solutions for schools. We're proud to be leaders in developing the technology that has the potential to reshape education in this country, as well as around the world, with changes more profound in the next two decades than we have seen in the past century.

Speaking for the IBM Corporation, I appreciate this opportunity to speak with you today and express our thoughts on the world of educational technology in the next twenty years.

Lou Gerstner, the Chairman and CEO of IBM, and author of Reinventing Education, has been a vocal and ardent supporter of K- 12 throughout his career. In fact, Lou and Governor Thompson of Wisconsin are working together right now on an educational technology conference for governors, chief state school officers, and business execu ives, that will be hosted at our IBM customer executive conference cente in Palisades, New York in late March. Lou tells a story that I have borrowed on many occasions ...

If a CPA fell asleep 50 years ago and awoke today, that CPA wouldn't be able to function in a modern office, because the tools have changed so radically. And the same would be true for a doctor, an engineer, a CEO -- even a politician. But if a teacher took that same 50-year nap, the teacher would wake up in a classroom that looks remarkably like the one he or she fell asleep in.

Frightening -- but true.

I am here to inject a sense of realism into all the excitement of technological change in schools. It's not happening! And unless we make dramatic changes -- nothing will happen 20 years from now.

The simple fact is that our schools are not changing in step with the rest of society. Despite technology spending of $3.4 billion annually in K-12 education, technology has not had a significant impact on the majority of teachers and students in this country.

Let me give you an example: Years ago we had typewriters in our school offices. Today, we have computers. But what are they being used for? Typing. Except, now we call it word processing. In most cases, we're still typing labels for manila folders and envelopes for mailing. In other words, we have a new tool being used in old ways. We're not doing electronic filing or E-mail, or using the additional power of the computer for spread sheets, data bases and communications.

The same is true in the classroom. While we now have on average, one computer for every nine children in K-12 education, these computers are either:

A) Used as presentation devices in group presentations, in place of the overhead projector or filmstrip

B) Placed in labs down the hall and used for word processing or teaching computer literacy, or

C) They are sitting in the corner of the classroom and are used for supplemental or remedial purposes at recess, lunch, and other non-teaching times.

Technology has not changed the basic classroom of 50 years ago -- we still educate our children with a teacher in front of the class presenting information.

If we are to compete and maintain our position as a world leader well into the next century, we must restructure the way we deliver education in this country and create a community of enthusiastic learners by:

- Exploiting technology to reshape the classroom, including the role of teachers, students and parents

- Applying this technology to a long-term plan -- technology, not for technology sake, but to produce specific learning outcomes

- Setting standards for achievement that align with the needs of business today and in the future

- Establishing and monitoring accountability for achieving these standards with measurable results

- Financing change appropriately-- as part of a long-term overall commitment for educational reform

- Linking spending to results.

Setting goals for U.S. education is one thing. Reaching them is another. I do believe that our schools today are better than they have ever been, but our progress on the road to education reform in this country is moving at a snail's pace, compared to what we must accomplish to attain measurable results for the National Goals by the year 2000 -- which is right around the corner -- or to prepare today's students to face the world 20 years from now. Why?

Advances in technology have made many of our public schools low-tech institutions in a high-tech society. The requirements and needs of education in our society are growing faster than schools are improving, and so a performance gap is growing. Our schools are falling behind because what we expect of them is increasing faster than their ability to deliver.

Consider some of the reasons driving these increased expectations. Changes in the workforce are a major factor. In 1950, 60 percent of the U.S. workforce consisted of "unskilled" labor versus 40 percent skilled, professional or managerial. By the end of last year, those numbers were more than reversed, with 67 percent being skilled, professional or managerial -- leaving a pool of only 33 percent of "unskilled" labor.

The equation has also changed due to advances in the body of human knowledge. For example, prior to the 1800's, an accomplished scientist was pretty much the master of all current scientific knowledge. Today, even with specialization, few can claim mastery of even a single field. As the physicist J. Robert Oppenheimer said, "These days, we know too much for one person to know much." In fact, the class of 2000 will be exposed to more information in just a single year than their grandparents encountered in their entire lives.

Given these facts, the requirement for higher-skilled workers, and the rapidly-expanding universe of knowledge, our thinking about education has to change.

The same technology that has brought cataclysmic change and greatly increased productivity to every facet of business, can improve the way we teach students and teachers. And it can also improve the efficiency and effectiveness of how we run our schools. In fact, technology is our only option to fundamentally change and improve America's educational system.

Let me share with you what technology can do and is doing in some of our schools, and what it should be doing in all of our schools.

Technology can change the role of teachers and students, and help to involve parents in ways not possible before. Teachers can provide one-on-one instruction, create team learning environments, and provide vehicles for students to learn how to think and access information through current technology; they can assume the role of coach, mentor, and instructional manager, while the student takes an active role in his or her learning experience. Parents and teachers can communicate electronically, bringing the parents closer to the classroom and the student's progress -- in real time.

Technology can reshape the very nature of the classroom. Students work together in teams. They don't necessarily sit in neat rows of desks facing the front of a traditional classroom. They learn collaborative skills, along with investigation, inquiry, observation and communications -- all the skills that businesses have been clamoring for, as identified by the Secretary of Labor's Commission on Achieving Necessary Skills (SCANS) report from the Department of Labor.

We can restructure education through the addition of technology and compelling courseware. But you can't have one without the other. An example is a current software product that allows students to go on their own field trip to the Great Smokey Mountains National Park, or to the St.

Johns National Park in the Virgin Islands. In this virtual reality setting, children are able to see and experience new things "first hand". It's the way students are doing research today in leading-edge situations. Online -- in full motion -- sound, pictures, moving images. In the short term, there is almost an "edutainment" aspect to preparing papers and studying for exams; in the long-term, students will learn and retain more information because of the delivery method. For example, viewing a world leader making an important address -- Martin Luther King delivering his "I had a dream" speech -- complete with the emotion of the moment and his commanding presence -- will have a far more lasting impact on a student than memorizing a few paragraphs from a traditional encyclopedia.

Computers will become vital teaching aids -- when they're integrated into the classroom and used to truly transform the way we teach. For example, a traditional class can be divided into three groups with one-third of the class working on computers. For a class of 30, that works out to be ten kids for five computers, with two students per computer. A second third of the class works on independent projects. The last third works with the teacher. We've now just changed the size of the class for that teacher from 30 down to ten students. This is a respectable productivity boost. The session begins with a whole-group discussion or activity, which includes demonstrations or video presentations on the computer. After this introduction, students work at the learning centers independently, with a partner, or in small groups. The activities they complete at the centers support and extend the concepts presented during the whole-group introduction. Each session ends with the class again coming together to share projects and review what they've learned. Students gain not only from independent study as they progress through interrelated activities, but they also benefit from cooperative learning. And, teachers are freed for small-group instruction. Flexible schedules permit time on tasks to be varied to suit individual needs, and shifts some of the responsibility for learning to the student -- discovery learning.

We are having success with this type of classroom today. At a school in Crowley, Louisiana, for example, students in an IBM Teaching and Learning with Computers (TLC) classroom performed as much as 23 percent higher on the California Achievement Test, than students in a traditional classroom. The TLC teacher reported a decline in discipline cases, improvement in student motivation and an increase in self-confidence and responsibility on the part of these students. Based on results, TLC was implemented throughout the school district the following year.

Similarly, in a suburb of Indianapolis, students scored in the top quartile and achieved gains of up to 22 percent in reading, language arts and math on the ISTEP Standardized Test after implementing TLC.

These examples are real; they are being done in innovative schools today, and meeting with excellent results. But unfortunately, these examples are the exception and not the norm in American schools -- they're isolated visions of what could be. And they leave untouched 90 percent of the teachers and students in America. The fact is, that after 15 years of putting computers in classrooms, nothing has really changed.

Why is this? It is not an exaggeration to say that most of the money spent on technology in this country is wasted. We spend about $3.4 billion annually on school technology, which is a little more than one percent of total spending on U.S. K-12 education. This is expected to more than double -- to $7.8 billion -- in the next ten years.

The problem is, that the focus of this spending is on technology infrastructure, not technology use. Most technology plans focus on getting computers for every five or six children, or on getting schools "wired". The related teacher training is focused on training teachers on computers versus training teachers on teaching with computers. As a result, there are numerous studies indicating that computers in the classroom don't "work" -- that is, they do not change educational outcomes. What these studies miss is that the technology was never planned to change outcomes. The technology plan was to have technology; there was no thought about what to do with it.

As I indicated previously, those schools that started with a focus on outcomes and chose applications accordingly, are getting extremely significant learning results from their technology implementations. If we are to be successful in the 21st century and make schools more effective, this order must not be reversed. As new technologies enhance the market, we cannot take our eyes off the outcomes expected and the learning results achieved.

No business today would purchase computers without having a specific application in mind for their use -- but schools are doing this every day. No business would rewire their offices for broadband communications without defining the return on investment expected -- but schools do this every day. No business would spend millions of dollars teaching their workforce new skills, without relating those skills to specific job performance expected -- but schools are doing just that with their teacher technology training.

Our public policy is encouraging these trends. Government views its role as providing the infrastructure, leaving the applications and use to private enterprise and the localities. Funding is provided for technology, and so technology is installed. Often, there is not money left over -- and generally there is no focus on the applications to be used with this technology or the educational results expected from it. Public policy must change to focus first on educational outcomes -- as the improvements we expect in educational performance -- and then focus technology spending on achieving those results.

In other words, technology in and of itself cannot alter education. It is a means to the end, not the end itself. Our schools will not change in the next 20 years just because technology is available. They will only change if we focus on and fund the purchase of applications for technology that will improve learning.

The second key to effective use of educational technology -- beyond focusing on outcomes and the applications that drive those outcomes -- is that we must retrain the workforce, our teachers. We are talking about fundamentally changing the structure of the classroom and the role of the

teacher; no business would alter its entire business model without a significant focus on retraining its workforce. This is not about making teachers experts on technology -- but rather expert in using technology to change the way they teach. This is not about using new tools in old ways, but rather it's about using new tools in new ways.

Therefore, my recommendations are these:

First:

Any government funding should focus aggressively on technology. Less than five percent of federal dollars in education is spent on technology. All of the other spending is supporting the status quo -- business as usual -- and will create little meaningful change in learning results. If we believe technology can and should change education -- if you believe, as I do, that it is the only option to create an order of magnitude change in education -- then government should be supporting it more vigorously.

Second:

Government technology spending must not focus simply on technology infrastructure. Classroom applications drive results in the classroom and are a key part of technology purchasing. Another key compent is is staff development -- not generic computer training for teachers -- but specific training on how to integrate technology applications into classroom teaching.

Think about an earlier time, and a new high technology tool that would revolutionize education. It had full motion video ... enabled instant sharing of information ... brought the world to life ... had a sense of realism -- virtual reality. Funding for this technology was a government priority. Sound familiar?

Well, I'm not talking about a computer; this was 30 years ago, and the revolutionary new technology was TV in the classroom. Today, TV's lie unused in schools and when broken are often not even repaired.

We've had computers in classrooms for nearly 15 years now; we've increased their number from 15 thousand in 1981 to 5.8 million today. Yet we've seen no changes, measured no successes, because we've also have no long-term plans or goals other than increasing the number of computers in our classrooms. To break this cycle, we must allocate funding for specific purposes, i.e., to improve math and reading in grades K-4, or high school science instruction, and we must tie appropriations -- especially continued funding -- to tangible results.

When we do this, our focus should be on applications and their effective use in the classroom. For every dollar spent on infrastructure, we need to spend another dollar on applications and related staff development. If we spend all of our money on infrastructure, we'll never move

from where we are today -- all we'll have is more expensive bells and whistles. Courseware is what gives life to the infrastructure; a retrained workforce of teachers who teach new things, in new and innovative ways, is what gives life to the courseware. Neither element can stand on its own. It's a package deal!

School reform is not a partisan issue -- we're talking about the future of our children, and therefore the future of this country.

Again ...

o Technology is the key to reshaping the way we deliver education

o We must never lose sight of a long-term plan that focuses on measurable results; we've been looking at technology but not outcomes for too long!

o We must set high standards for achievement -- standards that also align with the skills and knowledge that businesses are looking for to create the leadership of tomorrow

o And of course, we must finance all of these efforts at sufficient levels -- and by that I mean enough to make a real difference in results; appropriations must be based on achievement of expected results

o Funding must support more than just an infrastructure; equal emphasis must be placed on classroom applications and staff development.

We want to make sure that if any of our teachers fall asleep today in a classroom and wake up in 20 years, they'll have no idea where they are -- and not a clue as to what they're supposed to do.

Technology provides us with new opportunity. A great opportunity for real change. But with it, comes great responsibility. We have a big challenge ahead of us. We've got to make a difference. Together. Our children need it. Our society requires it. And our country demands it.

Chairman WALKER. Thank you, Mr. Mendenhall.

The Committee is now in a dilemma. We have a vote on on the floor. This is a vote to recommit the bill, which is obviously going to lose from the initial vote count, and then we are going to have a vote on final passage.

At that point, this Committee, meaning the Science Committee, has its bill on the floor.

So what I've asked to be done here is I've asked Mr. Ehlers to come back as Vice Chairman of the Science Committee, and begin chairing the Committee.

Mr. Joseph, I think what we will do is wait and take your testimony right after the vote is over. I apologize to the panel for this, and to the next panel for it, but we will take a break now.

We stand in recess to go vote, and then we'll come back and resume the session.

Well, as soon as the second vote is over, we intend to resume. [Recess.]

Mr. EHLERS. [Presiding]. I'd ask my colleagues to take their places, and we will resume the hearing.

We apologize once again to the panel that we were interrupted by a vote, and particularly apologize to Mr. Joseph. Unfortunately, that's a fact of life in this particular part of the world.

Once again, we thank you for coming and appreciate the comments we've heard thus far, and we'll turn now to Mr. Joseph, from the U.S. Chamber of Commerce, and look forward to your testimony.

STATEMENT OF MR. JEFF JOSEPH, VICE PRESIDENT DOMESTIC POLICY, U.S. CHAMBER OF COMMERCE, WASHINGTON, D.C.

Mr. JOSEPH. Thank you, Mr. Chairman, and I appreciate the opportunity to be here actually all morning, and now into the afternoon. It's been a very fascinating discussion. Obviously this is a topic of great interest to virtually every American and Congress must wrestle with what role, if any, should have in trying to accelerate this.

We appreciate you accepting our full statement into the record. In that full statement, we attempt to try and address all the fundamental issues you have in your background papers, so I'm not going to go into those in detail now.

But I would like to say that just listening for the last three hours sort of forced the last 25 years of my life to fly up before my eyes, to 25 years ago when I was an inner city classroom teacher in Baltimore, experiencing firsthand some of the problems with public education, to 1979, when I started teaching in graduate schools here in the DC area and started seeing firsthand why business people were saying that the product of education wasn't quite what they thought it once was.

To sitting with Ted Bell in 1983 when the Reagan Administration came out with the Nation At Risk document, and agreeing with him that chambers all around the country would hold meetings, so that he could be on the stump, and from the top down, tell people about why we needed to raise teacher salaries and adopt schools and support public/private partnerships and do all these

wonderful things, that we were going to try and put American education back on track.

To 1990 when President Bush and the governors went off to Charlottesville because the Nation At Risk warnings and the additional trillion dollars we spent as a nation on public education made no real impression in terms of outcomes.

To working with the Bush Administration to try and set up the New American Schools Development Corporation as the Bell weather leader that would show us how to bring in a new generation of schools so that we would have learners that can compete on the world scale.

To even being back here as a witness in the 1991 hearings that were originally held by the Science Committee on the importance and significance of educational technology.

And the reason I was here in '91 was because the business community has been at the forefront in understanding the significance of injecting technology into the school process, because the work place, as we all understand it, is much more sophisticated and it needs to be to be competitive in the global marketplace.

And when we surveyed 3,000 chambers back in 1990 about how we could most effectively represent them in Washington with regard to education and training reform, 2,000 responded that their highest priority we could do for them would be to get the Congress to understand that we had to get more technology into schools.

That was the number one recommendation from 2,000 chambers five years ago.

Now what we have, over the last decade, I mean, 10, 15 years ago when computers first came out into schools, the answer was, if we had one computer in a school, that would fix and start the restructuring process.

Then it became, well we needed one per classroom. Then we needed a full learning lab. Now we need to have access to the Internet.

Well, as far as I understand, the D.C. Public School System has access to the Internet and that Bell Atlantic wires outside the building can all get you there.

But 50 percent of the schools in D.C. inside the building have rotary phone lines, that won't allow them to talk to anyone.

And of all the other half of the schools that do have digital lines, only four in fact have modems that have them connected to the Internet.

But euphemistically, we can say all D.C. schools have access to the Internet, but the reality is that very few students and very few teachers here in D.C. even have a clue what the Internet is.

That's not to say that there aren't phenomenal things going on everywhere, and we've had a number of examples cited this morning. We've had them cited in articles and publications and tv documentaries over the last 10 and 15 years.

But the bottom line is, in terms of the totality of this country, how do we go to scale? How do we get technology into the classroom everywhere so it benefits all Americans?

And I don't want to make it sound like that technology is the answer, that there aren't these other issues that Chairman Goodling mentioned, like the dysfunctional family and other social problems

that are very much part of the equation with regard to the state of education today.

But it's not that complicated. The original, I think diagnosis goes back to Ben Franklin who said: "Tell me, I'll probably forget over time. Teach me, hopefully I'll remember, but involve me and I will learn."

And it's the technology coming into the learning process that allows for the involvement of young people today.

Young people go to school and don't find school is a very relevant place compared to the rest of their lives. The rest of their lives are spent in the fast pace MTV, video game, high tech world, and then by and large, they go to classrooms that haven't changed for 40, 50, or 60 years.

The notion of redesigning schools is a wonderful idea, but there are too many communities in this country with hundred year old school buildings that they can't even restructure because they have too much asbestos in the ceiling, and so they have the dilemma of we better leave it alone, rather than trying even to take it out.

We also have the dilemma of the communities trying to figure out where they find the money to do everything because the public at large has grown somewhat queasy abut being willing to put more and more money into local school systems, because we've been talking about fixing education in this country for 15 years with no real discernable results.

And so the issue is how do we go to scale, both financially and technologically. How do we get each of the classrooms in America to have that optimum ratio of one computer for every three students, and how do we make sure that each of the two and a half million teachers in this country are trained and understand how to best maximize what their role is in the classroom, how to bring instructional material in line with the curriculum in the preordained tests that are presumed to be the diagnosis of what we know in this country, and how do we do that in anyone's life time?

Because, as I sit here, and I said as I listened, I saw the last 25 years of my life in terms of involvement with education sort of go through, we're only 50 months away from the year 2000.

President Clinton is challenging industry leaders to wire up every classroom by the year 2000. That means we have to do 50,000 classrooms a month between now and the year 2000, 50,000 a month, just straight mathematics.

Obviously, we're not doing 50,000 a month.

Now if we were to decide we could only do 10,000 classrooms a year and train 10,000 teachers a year to maximize this potential we're giving them, which would be a huge challenge, at the rate of 10,000 classrooms and 10,000 teachers a year, it takes you 250 years to get to all 2.5 million classrooms and all 2.5 million teachers.

So the issue I think before Congress is reflective of the broader debate that's going on here in this town, which deals with the real relationship between the federal government and the state and local governments, and where power resides and who's going to be responsible for what programs.

And of course we know that most money in education is not federal.

But conversely, the states are going to be asked to do more and more in different areas, and they're going to be wondering where they're going to be doing it, and from what sums.

Yet, we have a general consensus in this country that adding educational technology to the learning process would be good for our children. It's essential in terms of retraining adult workers. It's essential for retraining senior citizens who want to go back to the work force.

It is the state of the art in terms of the kinds of curricular materials that are being developed in this country. And it begs the issue, why can't we collaboratively, federal, state and local, come up with one plan that everyone buys into that says, not unlike a hundred years ago, that that one-room school house was the center of the community, where all the students went.

That the schools become the center of the learning universe in every community and collaboratively government and the private sector think through their education and training needs and make sure they channel those resources into those school buildings so that every community suddenly finds the resources, and the customers, if you will, who will pay for the expansion and development of the kinds of learning technologies that are so dramatically needed.

Now, if we can't figure out how to pay for it, how is the rest of the world going to figure out how to pay for it? Because the reality is in the global marketplace, if you don't have world class workers, you're not going to survive.

And yet, lesser developed countries already have proposals before the World Bank and other international lending agencies for them to fund the kinds of systems I'm talking about, where government themselves become a user of these technology platforms, because they've got to figure out something to do with their people anyway, and a better way to deliver government services.

So if they can get private sector investment to set these technology learning centers up and commit to use them over a period of time, the funds will flow to do this. And this is an idea, as I said, that there are proposals in the World Bank right now.

So the rest of the world is moving in this direction. In some instances, it's going to be easier for some countries to do this because they have dictatorial, autocratic systems. They'll say, as they're doing in China, let's do this, and they'll do it.

We have 15,300 local school districts that each have to come to agreement on what they want to do.

And I've seen, as I said, for the last 15 years, there's never consensus on the part of each of the 15,300 school districts. They all are trying to do the right thing. They all are doing positive things, but they all aren't doing things that synergistically bring you a national plan that works for the whole country.

And so, you know, what I'd like to draw to your attention and to the members of the Committees, especially because both Mr. Goodling and Mr. Walker are from Pennsylvania, an interesting project going on in Pennsylvania and four contiguous states, West Virginia, Virginia, Maryland and D.C., where the state governments are working in conjunction with the National Guard.

The National Guard has a need for high tech training in all the communities for the Weekend Warriors. The National Guard can't afford to build the same technology platforms over and over again, with technology continuing to change, but they can afford to make use of them, or rent their time on the system.

National Guard also has historic commitments within the State of providing a lot of civic services, and doing other things that correspond with their existing series of missions.

And so in Pennsylvania, for example, a new coalition, the Pennsylvania Information Highway Consortium, has come together with the leaders of the Pennsylvania Chamber of Commerce and the State Telephone Association and the State Cable Association, State Public Utility Association, the State Rural Electric Coop Association, and the major educational institutions like Penn State, and they are collaboratively thinking through how do we have our members make use of the sites that DoD also wants to make use of, and there are ten locations already identified in Pennsylvania where they are collaboratively working.

And I also append to the back of the testimony, an interesting series of articles from Huntington, West Virginia, because West Virginia is one of these pilot states also, where, in a week's period of time, this was the only thing in the newspaper, where the local chamber has a meeting and people come together and they start thinking this thing through and suddenly the whole town's talking about how do we collaboratively come together and figure out the economics and make this thing work.

So what I'm suggesting to the Congress and to policymakers is that we have to think about going to scale in someone's life time which is going to require bigger models than one company and one school district or one state; it's got to be multi-state, it's got to be national, and has to fit into the international framework of global competition.

Thank you.

[The prepared statement of Mr. Joseph follows:]

STATEMENT
on
EDUCATIONAL TECHNOLOGY IN THE 21ST CENTURY
before the
HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
and the
HOUSE COMMITTEE ON ECONOMIC AND EDUCATIONAL OPPORTUNITIES
for the
U.S. CHAMBER OF COMMERCE
by
Jeffrey H. Joseph
October 12, 1995

I am Jeff Joseph, Vice President for Domestic Policy at the U.S. Chamber of Commerce. I also serve as Executive Vice President of the U.S. Chamber's education and training affiliate, the Center for Workforce Preparation.

The U.S. Chamber of Commerce commends the House Committee on Science, Space and Technology and the House Committee on Economic and Educational Opportunities for recognizing the relevance of educational technology to America's economic vitality and competitive strength. The U.S. Chamber also appreciates this opportunity to present the business community's views on this critical issue.

The intense interest of business in education and training issues is motivated by survival. The difficulty of finding qualified employees to perform in today's sophisticated high technology workplace is a recurring nightmare for more and more businesses, large and small, in every part of the country. A significant number of recent graduates of both secondary schools and postsecondary institutions are not able to assume productive places in business and industry.

Even as many corporations are conducting expensive nationwide searches for qualified employees, thousands of job applicants are being turned away from corporate personnel departments because they lack the basic skills required to function in the workplace. By and large, these disappointed job seekers are individuals who, in an industrial era economy, would have been able to acquire and keep well-paying jobs in business and industry.

There is a conspicuous skills gap among our working population today that is extremely distressing to both business and workers and which presents a major challenge to our social stability and economic vigor. Political pundits and social commentators have noted the stagnant middle class and rising frustration among blue collar workers unable to keep pace with inflation or hope for a better future. Those on the political left blame business, foreign competition and a lack of union influence. Those on the political right blame declining social values and an eroding work ethic. While there may be some merit to any or all of these claims, none of them addresses the core issue.

The world is immersed in a rare and unprecedented era of technological transformation that is rapidly remaking virtually every aspect of the way we work and live. The computer chip was an unprecedented breakthrough greater in its implications than the internal combustion engine, the telephone and the radio. While the machines of the industrial age magnified the power of the human muscle, the computer chip magnifies the power of the human mind. The impact is awesome because intellect is the greatest power of all.

The influence of the chip is growing exponentially. Twenty years ago there were only 50,000 primitive computers in existence and a like number of people who could handle them. Today, 50,000 computers are sold every ten hours, an explosive marketplace driven by a growing throng of eager enthusiasts constantly seeking out new applications for the extraordinary power placed at their disposal.

Thus, the computer chip is wafting back and forth through our economy wreaking creative destruction in its wake, as millions of people daily discover fresh ways to use it to achieve ever higher levels of efficiency, quality and productivity. Within that context, everything is changing and nothing is sacred.

The job skills which yesterday seemed timeless are today rendered obsolete overnight. Workers no longer operate the machines of heavy industry; they monitor and program the computers that operate the machines. A handful of workers produce more than thousands could ten years ago. In this rapid-paced high tech modern workplace the workers must be highly literate and computer friendly and able to relearn their basic skills constantly.

This situation evolved seemingly overnight and caught much of American business and industry off guard and unprepared. In the modern world, complacency is a guaranteed one-way ticket to bankruptcy. To remain competitive in the world marketplace, business must stay ahead of the technological curve and be committed to constant innovation and improvement. To do that, it must have a highly trained, educated and motivated work force.

Within that context, we as a nation have a serious problem. Our schools simply are not producing graduates capable of functioning in the modern high-tech workplace. Indeed, an incredible number of students at two-year technical community colleges are university graduates with four-year degrees who have gone back to school seeking practical skills which they can market to employers. The problem is not necessarily that our schools have deteriorated, but that the standards of yesterday are no longer sufficient for the needs of today. We must find a way to inject modern educational technology tools into the lifelong learning needs of all citizens.

All across the country, tens of thousands of business people are working through the chamber of commerce federation to help their local schools improve the quality of education and synchronize their curricula with current business needs. To help coordinate this movement in 1990, the U.S. Chamber created the Center for Workforce Preparation. At that time, the Center surveyed 3,000 state and local chambers of commerce to determine their specific interests in education and training.

More than 60 percent of the chambers responded, reflecting broad interest in education and commitment to change. Their top priority was gearing education to accommodate the new business reliance on sophisticated technology.

These survey results, taken five years ago, in combination with growing national recognition of the academic and economic benefits of computer-based instruction, prompted the U.S. Chamber and Center to take an early role in promoting the installation and use of educational technology in schools throughout the nation.

In June 1991, I shared information on our plans to promote community-wide understanding of, and use of technology to create a nation of intelligent, informed and involved citizens with the Subcommittee on Technology and Competitiveness of the House Committee on Science, Space and Technology. Since then, the U.S. Chamber and Center have pursued this deep commitment to improving education and workforce quality through advances in teaching and instruction made possible by computer, software, and telecommunications technology.

Let me emphasize that technology, by itself, is not the answer to anything, especially education's many problems. But it is a powerful catalyst which will help force the restructuring necessary to align our educational system with the 21st Century's knowledge requirements and workplace opportunities.

EDUCATIONAL TECHNOLOGY: A CATALYST FOR ECONOMIC AND COMPETITIVE STRENGTH

Current trends indicate we are far from producing the world-class workers needed in today's high performance work environments. In August 1995, the Chamber surveyed the readers of our magazine, *Nation's Business*, about their education and training needs and priorities. A full 93 percent reported that new employees lacked adequate job skills and preparation. A whopping 97 percent reported that skill levels had either declined or remained the same in the past five years. Thus, efforts to upgrade the skills of American workers will continue to be at the forefront of the business community's agenda for the

foreseeable future.

There is a growing body of evidence from research, schools and workplaces in a variety of settings around the country that sophisticated communications technologies offer the promise of quantum advances in education and learning through more individualized instruction. In part, this is simply because modern students and workers are much more acclimated to using advanced technology than earlier generations were, and commensurately less receptive to the old, pedagogical teaching technique. In part, the very act of collaborative learning via a mix of classroom instruction and interactive programming serves to familiarize today's students with the technology and the teamwork skills they will need in the workplace, and which they will need to use to acquire further education in the years ahead.

The advantages of applying high technology to education and training only begins there. Properly used, the high tech classroom can accommodate all students at their individual speeds and needs. Thus, teachers will no longer be required to seek out a middle ground of progress, leaving slow students behind and boring brighter ones. By merging interactive technologies with other teaching techniques, instructors can accommodate each student's abilities and interests.

But the greatest advantage of technology-assisted education is the intrinsic ability of the technology to access a vast range of learning materials at the touch of a button, including special education software and instruction modules for students with disabilities. Every desk can become a power learning center where a student from the poorest, most limited circumstances will have instant access to virtually the entire realm

of human knowledge. Young people, regardless of social and economic background, will be able to peruse the racks of the Library of Congress, stroll the halls of our great museums or monitor lectures by the world's great scholars.

For many years now, practical experiments have confirmed the potential of this visionary perception of the possibilities of technology. Almost five years ago, a Congressionally mandated comparison of multimedia instruction with traditional approaches to education found time savings of 30 percent, improved achievement, cost savings of up to 40 percent, and a direct, positive link between the amount of interactivity provided and instructional effectiveness (Machine Mediated Learning, 1991). Research in military training conducted by the Institute for Defense Analyses (Alexandria, Virginia) has found that students reach desired levels of achievement in 30 percent less time than students engaging in more standard approaches to training. A comparison of four instructional approaches: peer and adult tutoring; reducing class size; increasing the length of the school day; and computer-based instruction, has found educational technology to be the least expensive and most effective instructional approach for raising mathematics scores (American Educational Research Journal, 1990).

PROGRESS IN IMPLEMENTING EDUCATIONAL TECHNOLOGY IN THE NATION'S SCHOOLS

In recognition of the academic and social benefits that can be derived from educational technology--and in an attempt to make that technology more affordable--

government leaders at the state and federal levels have launched a variety of initiatives to install computers and needed forms of telecommunications linkages in our schools and learning establishments.

Since the outset of the decade, much fanfare has been made about progress to implement educational technology in our nation's K-12 school system. According to Quality Education Data, since 1991, the percent of schools with local area networks has increased from three to 22 percent at the elementary level, and from 10 to 48 percent at the senior high level. During this same time period, the percent of schools with a satellite dish has grown from one to seventeen.

Although they appear promising on the surface, these figures also indicate that most computer technology introduced into public schools involves individual, low-power computers which lack the ability to be centrally networked. While such devices possess some rudimentary uses, they are but the harbingers of the real electronic power by which each workstation can reach when it is patched into appropriate learning channels.

Thus, while modest progress has been made, it remains painfully clear that our nation still has a monumental way to go. The slow growth of computer-based technology in the schools is due to a number of complicated factors. Resistance on the part of educators has recently begun to thaw. A recent edition of the magazine *Curriculum Administrator*, reports that only 36 percent of teachers indicate a newly-found willingness to change what they do and incorporate technology into their daily lesson plans.

Even if teachers were clamoring for these advances, school systems have been frustrated by the failure of instructional materials to easily align with text and approved

curricula, not to mention the problems of aligning incompatible hardware and software.

To be pervasive, educational technology must be in every classroom, not just in isolated learning laboratories; educational software must cover all grade levels and be applicable across state lines. Then, there is the issue of the appropriate ratio of computers to students. Educators and scholars believe an optimum ratio is three students to each computer. Achieving this end could require an investment of more than $50 billion, assuming that 10 work stations are installed in each of the nation's more than 2.5 million classrooms, at an approximate cost of $2,000 per station. Regrettably, this estimate does not account for the costs incurred for networking, software installation, teacher training, software purchases, increase in use of electricity, connection of phone lines, or the upgrading of school buildings.

This implies it will take a while, probably a decade at best, as communities seek to phase these costs in while realigning other expenses. This exercise already has begun. A number of school districts have undertaken the exercise of assessing their current spending patterns through another initiative by the Center for Workforce Preparation, in conjunction with the national accounting firm, Coopers & Lybrand. School districts undertake a sophisticated accounting exercise to better understand how they spend the substantial sums they currently manage. Software will soon be made available to all school districts to inexpensively, and quickly, determine how to effectively target scarce resources. A preferred outcome is that school redeploy funds to purchase educational technologies.

This process is an important step as communities begin to think about how to affordably realign their educational systems to satisfy 21st Century needs. All long journeys begin with a single step, and the road to finding the funds to bring educational technology to every learner's desk is perhaps one of the most challenging efforts ever faced by a community.

Simply put, the numbers involved, and going to "scale" is a much bigger challenge than we understand. The public keeps hearing of exciting new demonstration projects to bring technology to classrooms. The Clinton administration announced several earlier this week. Other efforts will be discussed today. But let us put the numbers into perspective.

How do we affordably replicate initiatives, once the original federal grants or corporate largess dry up? Historically, federally-funded grant efforts are best sustained by obtaining additional foundation support and other grants. And corporate efforts last as long as individual corporations can afford to undertake them. Today's economy and levels of government funding suggest this traditional approach is no longer viable. A way must be found to make this country's need for lifelong learning pay for itself.

How big is the challenge? Bigger than the public has been led to expect. Earlier this week, it was reported that 874 schools in the United States have developed their own Web pages on the Internet. While this sounds impressive, what percentage of schools does this include? The answer, is less than one percent.

The facts are straightforward. There are approximately 50 million children in grades K-12. There are 2.5 million teachers. There are approximately 100,000 school

buildings (public and private). If as a nation, we agreed that we were going to proceed at a pace of wiring-up 10,000 classrooms a year, and providing quality instruction to 10,000 teachers per year (to learn to optimize their new roles s "guides on the side" instead of the century's old model of being a "sage on the stage"), it would still take 250 years to reach all classrooms and teachers throughout this nation.

The challenge, of course, is how to accelerate this vision so it takes place as soon as possible. The amount of money involved in a potential market this size captures the interest of many players, but also raises a variety of complex legal questions regarding the technologies to sustain the information networks and the proprietary rights of the industries which provide competing technologies.

The issues are not small because everyone recognizes that this is where the future lies and with it either fortune or penury for the competing interests which seek to participate. For obvious reasons, educators are determined to assure minimal costs for the operations of such a system, while the private sector needs to realistically price their services to recapture costs plus an appropriate profit, if they are to remain viable as economic enterprises. The riddle is how to assure evolution of an equitable and cost effective system within the context of the free market which assures integrity and efficiency.

12

A WORLDWIDE PHENOMENON--
SEIZING THE POTENTIAL OF EDUCATION TECHNOLOGY

Our awareness of the vast potential of modern communications technology to help resolve many basic challenges, including the most critical one of promoting educational excellence, is far from unique.

Recently, world leaders from most nations convened under the auspices of the United Nations Social Summit in Copenhagen, Denmark, for a full scale exploration of how the ancient social challenges such as meeting mankind's basic needs for shelter, food, medical care, and literacy can be most effectively addressed. A major subtheme which emerged, and will be the subject of followup activities by the Summit's organizers, is designing community-based public-private partnerships to use the power of digital technologies for learning, training and information dissemination.

While many question the UN's historical contributions to social and economic progress, based upon often meager achievements, it is clear that the leaders of many influential nations understand the utility of quickly deploying these technologies for the education and training of their people.

For example, the Chinese have been buying personal computers as fast as they can. China's Ministry of Agriculture is now setting up tens of thousands of local Township Enterprises which are basically co-operatives in which local businesses work with government leaders and educators to focus on making their products more viable in the export marketplace. They recognize a critical need to develop a world class work

force which is on the cutting edge of emerging technologies, and efficient, cost-effective uses of modern communication and educational technology to grea'', facilitate this development.

In South Africa, major banks, corporations and software industries are working within a public-private partnership to structure digital community-based learning hubs where the impoverished black major.ty will have access to world class education and training opportunities.

In Japan the government has committed vast resources to creation of a nationwide information grid that will soon be available to every citizen. While the Japanese model for education may be too inflexible to accommodate the rapidly changing demands of modern technology, Japan nevertheless will have in place the technological basis for more creative applications as they are recognized and embraced.

In Great Britain, Training and Enterprise Councils (TECs) provide a bridge between the public and private sectors in 82 locations throughout the nation. They involve both public and private sector funding and have close working relationships with local education institutions as they seek to address local issues of employment generation, small business development, and training for industry and community mobilization. Plans are now underway to expand the educational technology component of these efforts.

The European Union as a whole (DG XIII) is developing a plan to expand distance lear, ıg and other educational technology applications across the multi-lingual European landscape. While it looks to the United States as a source of expertise in

designing and perfecting these technologies, it aspires to surpass us in terms of rapid deployment.

These discussions and related efforts already underway are forcing the World Bank and related organizations such as the Inter-American Development Bank to rethink their role and conceptual approach to promoting educational and training opportunities in the developing world. Most international funding agencies are independently supporting technology based initiatives in their respective fields. Very few of these are financially sustainable. A growing number of participants are beginning to realize that the key to full development of such systems is a broadly-based user community which achieves full use of the systems, hence providing the political support and income stream required to sustain and expand their use.

To some extent, foreign nations have an advantage over the United States in building new, technology-based education and training systems because they have relatively primitive educational and information bases to build upon, and hence they encounter less resistance to change and innovation from entrenched bureaucracies and other powerful interests. Likewise, many other nations can rely upon relatively efficient top-down administrative structures to impose dramatic restructuring across the board with minimal opposition.

Such is clearly not the case in the United States where we have in place a fairly refined educational apparatus in 15,300 local school districts, each supported by a powerful bureaucratic infrastructure with strong ties to local, state and national political organizations. We must also contend with powerful labor unions which resist many

attempts to impose higher levels of accountability among their rank and file members. In such an environment, any degree of real change is hard to achieve.

This is not to imply Chamber support for a top-down educational system. America's strengths are at the grassroots level, and individual states and communities are the appropriate administrators of their educational systems. The challenge in the information age is how to bring technical interoperability to an educational technology system in schools and communities that flows across different brands of hardware, software and different modes of telecommunications linkages.

Perhaps most intimidating of all is our recent history of ill-fated reform programs that have cost tax payers vast sums without commensurate improvement in educational performance. Our citizens are quite understandably skeptical of new reform schemes and our taxpayers are increasingly hostile to new initiatives that require ever greater infusions of their dollars but which offer little if any return on the investment.

Thus the challenge of realizing the potential of modern technology is most intimidating both in terms of the resources required and also in terms of overcoming bureaucratic resistance and persuading millions of educators, administrators, parents and students to embrace unfamiliar technology.

However, while the educational establishment has to some extent squandered its credibility with the voters and taxpayers, the U.S. military was moving on a parallel track toward the same basic objective which is fuller use of modern education technology and development of a larger population of individuals qualified to operate the sophisticated systems they need that already exist, and which will become even more sophisticated in

the new century.

The military's primary concern is making certain that the citizen soldiers who comprise the backbone of our national defense apparatus, the National Guard and Reserves, regularly have access to the most modern training techniques that are currently available only to active duty personnel. The military quickly saw the use of a myriad of educational technologies as a major part of the solution. In looking for a practical, cost-effective way to link up to 5,000 existing sites where National Guard and Reserve units convene, the Department of Defense (DOD) concluded that such a system would be infinitely more useful and affordable if its range of potential applications were greatly expanded to serve other legitimate community groups whose needs coincide with appropriate existing missions. This is fully consistent with the National Guard's traditional role as a base for a variety of positive community social and economic activities.

In 1992, under Secretary of Defense Dick Cheney, the Reserve Forces Policy Board formally proposed that such a community-based learning system be supported. As a result, the Applied Research Projects Agency (ARPA) funded engineering studies in search of a framework through which existing digital learning technologies, often deemed incompatible with each other, could be made functional within the context of one coherent system. A major concern is the issue of technical interoperability, considering the potential broad range of users and their needs.

Under the guidance of DOD, leaders from business, education, technology and the military worked with ARPA to develop a plan for this concept that would

simultaneously address the needs and requirements of each. The result was creation of a not-for-profit entity, the Community and Learning Information Network (CLIN), which was envisioned as a catalyst to enable community groups to come together within the context of private sector networks. It was and remains a guiding conviction of the CLIN vision that the private sector should provide the basic information tools and technologies for the new system. Once the full plan was operational nationwide, CLIN would be disolved.

Indeed, by accelerating the use of educational technologies, CLIN's goal is to forge a viable consumer-driven marketplace for educational technology. A vital component of this approach--and one whose significance I cannot stress enough--is the concept of shared usage by which a variety of community users will assure an uninterrupted stream of revenue to sustain the system and render it rapidly expandable.

Hence we have before us a model now being deployed as a DOD distance learning pilot program in five jurisdictions, which will demonstrate how communities can address this challenge cooperatively. The jurisdictions are Pennsylvania, West Virginia, Maryland, Virginia and the District of Columbia--the home states of many esteemed members of these committees, including the chairmen of both. The commitment on the part of the broader user community to assure full development and financial support for the system is being developed by the National Guard in conjunction with CLIN and its state partners.

In these five jurisdictions, this system is becoming the catalyst for community participation it was designed to be. State and local governments and industry are all

moving to contribute resources to the plan. For example, attached to this statement are copies of several articles from The Herald Dispatch, the newspaper of Huntington, West Virginia, describing activities by local community groups working with each other to develop a CLIN site in accord with that community's particular learning needs and available facilities. Coordination of activities within the state of West Virginia are being managed by Software Valley, Inc., a ten-year old statewide not-for-profit entity which has almost 3,000 members.

In Pennsylvania, while the first 10 sites will likely be in military-related facilities, the governor has begun to consider how these sites can be used for other state training needs. The newly appointed state Chief Information Officer has been mandated to create a State Information Enterprise Plan, and it is anticipated that the shared usage capabilities of these sites will become an integral part of this plan. The Pennsylvania effort is being directed by a newly established Pennsylvania Information Highway Consortium, supported by that state's major institutions. Examples of those institutions include the Pennsylvania State University, Pennsylvania Chamber of Commerce, and the state's Cable Television Association, Public Utility Commission, Telephone Association, and Rural Electric Association.

These are only a few random examples. As this distance learning pilot program develops over the next few months, we will acquire a greater range of experience and begin to develop a track record establishing the viability of the shared usage concept to sustain and expand the system. The U.S. Chamber's Center for Workforce Preparation will be monitoring progress to determine its viability as a model that local and state

chambers of commerce in more than 3,000 communities may wish to adopt.

Attached are Appendix A, which responds to the specific issues and questions posed by the committees in their background papers, and Appendix B, which includes news reports from Huntington, West Virginia, regarding the work of community groups to establish learning centers as part of DOD's new five-state demonstration project.

ATTACHMENT A

ISSUES FOR THE FUTURE:
U.S. CHAMBER OF COMMERCE RESPONSE

School Structure

Will we still have the existing K-12 grade structure twenty years from now?

Educational technology does warrant a different type of classroom. However, and unfortunately, at the rate the nation is proceeding, the K-12 structure as we know it today will undoubtably still exist in many communities in the year 2015. America has been attempting to "reform" education since 1983 when A Nation at Risk was released. The nation was again mobilized to improve education in 1990, when the National Education Goals were adopted by then-President Bush and the nation's Governors.

Today, we are in the midst of an era when rapidly evolving multimedia technology and telecommunications are finding their way into American classrooms. While the physical structure of many, if not most, public schools will still be in existence twenty years from now, technology promises that what goes on in the classrooms could be radically different. Students probably will still be grouped by age for social interaction reasons, but, with the help of multimedia learning materials that reside at the school and provide access to materials worldwide via telecommunications, students could learn at their own pace in the mode most appropriate for them.

In addition, the role of the teacher could change from a dispenser of facts to a facilitator of information gathering and/or as a guide for synthesizing and applying that information. The classroom of twenty years from now could take advantage of research showing that interactive, involved learning is the method that gets the best results. Thus, a report from Curriculum Administrator which currently states that only 36 percent of America's teachers are presently enthusiastic about computer technology could become ancient history.

Will increased networking cause traditional geographical and jurisdictional boundaries to blur?

Yes, increased networking will cause traditional boundaries to blur. This is especially true for students who move frequently, such as the children of migratory workers. However, the effects of networking will not be limited to special student populations.

With effective educational technology, students throughout the nation (and even the world) with special interests and/or aptitudes will be able to accelerate at their own pace. All students will be able to access courses and instructors that suit their needs and interests no matter where their school is located or what it offers on campus.

How will educational technology impact education in the schools?

The impact could be very positive. Because educational technology makes it possible to individualize instruction, all students with access to computers will eventually be able to work at their own pace using a learning style that best suits their needs. In addition, students will theoretically, at least, have unlimited access to the most effective and appropriate multimedia instructional programs, as well as growing amounts of excellent instructional materials on the Internet.

But to be pervasive, computer hardware must be in every classroom, not just in isolated learning laboratories; educational software must cover all grade levels and be applicable across state lines. Achieving this end could require an investment of more than $50 billion (assuming that 10 work stations are installed in each of the nation's 2.5 million classrooms at an approximate cost of $2,000 per station). This estimate does not account for the costs incurred for networking, software installation, teacher training, software purchases, increase in use of electricity, connection of phone lines, or the upgrading of school buildings. In Fairfax County, Virginia, a school district relatively well able to afford computer installation, only 10 of 184 schools are networked.

Will the easy availability of quality instructional material to anyone with a computer terminal tend to fragment the traditional school structure?

If charter and/or magnet schools continue to be the prime beneficiary of computers, then the traditional school structure could become fragmented. However, if a more rapid installation of computers in the schools can occur, then educational technology can soon serve as a synergistic healer, and the traditional school structure will be enhanced. That will occur when pilot schools are established, and the pilot is duplicated throughout the region.

Will the schools have a role in lifelong learning and remedial learning?

Absolutely. In the most effective scenario, students will be exposed to multimedia learning by dav; adults will benefit from their use in the evening. All learners, irrespective of age, will be able to access these and other instructional materials from remote sites, including their homes. This scenario is reflective of the "shared usage" concept in the newly intitiated five-state distance learning

project of the Department of Defense.

How important is it to have assured, affordable access for all schools to the broadband international communications network?

It is essential. Without it, the gaps between the information "haves" and "have-nots" will become even greater, and our nation will become even more polarized. But the key in this question is "affordability." Computer hardware and software are here to stay; affordability is a challenge we need to overcome.

The telecommunications reform bills (S. 652 and H.R. 1555) heading to conference do not "ensure affordable access to broadband communications services for all schools" as otherwise suggested. Both pieces of legislation use the broad rhetoric of access, yet simply rely on the Federal Communications Commission (FCC) to find the solution. And, the tools available to the FCC, regulatory sticks and carrots, will not do the job.

Asking whether schools should have assured access to advanced broadband communications begs the questions of affordability and who pays. Hooking up a school to broadband services involves more than plugging a cable into a school. The cost of retrofitting an entire school to accept the technology, never mind software and hardware expenses, is daunting to all but the richest school districts.

S. 652 and H.R. 1555 also assume that the telecommunications industry will soon have the infrastructure in place to actually hook up every school in the country. Currently, old copper lines run through almost every community in the country. Inadequate for handling the large data transmission requirements of broadband service, they will have to be replaced with fiber optic cable. Eventually this system may be surpassed by wireless technology. The legislation simply requires the FCC to ensure schools access to advanced communications services if a common carrier establishes those services. This is little assurance if the infrastructure does not materialize.

How will we manage the cost of this new technology?

The federal government spends substantial amounts of money on research and development for educational technology with too little coordination. An effort must be made to come to consensus on a plan for deployment that is replicable both technologically and financially.

For example, government at all levels--federal, state and local--has its own internal training needs. Fulfilling these needs at local sites through the shared usage concept, where students use computers for learning by day and adults

pay for use of the technology during the evening and on weekends, will greatly accelerate the process by reducing the amount of funding required.

Will the teacher teach technology?

To "teach" technology, educators must learn how to integrate technology into the required curriculum. The problem is that higher education institutions continue to lack the technology needed to train teachers. Therefore, to have access to computers and understand their pedagogical value, teachers colleges must also become equipped with educational technology.

In addition, practicing teachers must learn to be comfortable with technology and how to integrate technology into the learning process. To some extent, this represents a paradigm shift for teachers. It will not happen automatically. Therefore, the availability of technology must be associated with a systematic in-service teacher education program.

The Teacher's Role

Will the role of the teacher change as a result of bringing technology into the classroom and home?

Yes, the teacher's role will change from the "sage on the stage" to the "guide on the side." However, this change will take place only if pre-service and in-service teacher education programs are changed to include the application of technology.

Are we approaching the age of Socratic one-on-one teaching?

If incorporated properly, multimedia computer-based technology provides an ideal mechanism for individualized instruction that goes beyond teaching basic subject matter. With appropriate software, students can acquire team building skills and the attitudes needed to be effective in the workplace. Motivation for peer competition need not be lost; students can compete and cooperate with others across the nation and even around the world through computer technology. Competition also can be intrinsically motivated, where students compete one-on-one with themselves.

Will we see an increase in team learning?

As indicated above, there is an opportunity for computer-based learning to help students develop the skills needed to be effective team workers -- a quality emphasized by businesses as essential for success in the workplace.

Technology supports and enhances every type of instructional approach, from large groups, to collaborative small teams, to individuals working at their own speed and with materials that support their personal learning styles.

The Industry Role

What is the predicted size of the educational technology market over the next twenty years?

Without a doubt, the size of the educational technology market is huge, and will continue to grow. When viewed as a lifelong learning tool, the sales of hardware, software and systems could realistically surpass those of the entertainment industry in the next twenty years.

According to the Office of Technology Assessment, the ratio of computers to students in today's schools is 1:12. Unfortunately, over half of the computers reflected in this ratio are very antiquated, and cannot even be networked. Ideally, America needs to have at least one computer per every three students for educational technology to reach its fullest potential.

Who should have the principle responsibility for evaluating computer-based instructional material?

At the state and local level, all stakeholders -- including business, education, parental and government leaders -- should have responsibility for reviewing computer based instructional material. The beauty of technology is that inclusion or exclusion decisions, based on local values and wishes, can be almost automatically initiated.

How can industry and schools work more cooperatively to ensure graduates are "workplace literate?"

With or without educational technology, there is a need for students to have meaningful exposure to the workplace before graduating. Efforts to establish school-to-work transition programs are escalating at the state and local level throughout the country -- many developed through local chambers of commerce. School-to-work initiatives can be complemented by applying the shared usage concept -- where business persons utilize the same computer technology as students do during the day and/or evening.

Will industry be able to transfer the outstanding training technology it has developed to the traditional education community?

The question is misleading, and targeted to larger corporations that possess the financial and human resources needed to make meaningful investments in computer technology in the workplace and in local schools. The role (and corresponding needs) of small business cannot be overlooked. Providing all adults and youths equal access to educational technology can best be achieved by applying the community-based, shared usage approach.

What elements of industry are likely to be major players in educational technology?

Obviously, the traditional hardware, software, systems, and communications providers (including telephone, satellite, and cable pro· ·'ers) will continue to make the biggest contribution. Other players, such as electric utility companies, are emerging as major players.

The Long Term Government Role

Should the Federal Government have a role in centralized R&D or in setting up pilot schools?

The federal government should focus mostly on basic research. There are not enough federal funds to set up enough pilot schools to really make a difference. What is needed is a coordinated strategy which channels federal training funds into community learning sites around the country which proliferate the concept in a market driven environment.

Standards and Certification.

Educational software should be oriented toward equipping students with the academic and occupational skills needed in the modern workplace. These skills also are needed to mold informed, involved, and thinking citizens. The DOEd asserts that over 44 states are in the process of developing academic standards; the U.S. Departments of Labor and Education are helping with over 20 projects to establish industry-specific skill standards.

While computer software should "teach to" academic and skill standards, it need not be a responsibility of the federal government to certify and police those standards. Traditionally, not-for-profit entities at the national level insure that products that need a certain amount of uniformity, such as fonns of educational technology, reflect today's academic and skill needs. And

businesses must be centrally involved in all aspects of developing standards and related assessments and certifications.

Affordable access.

As mentioned, the telecommunications reform bills are not likely to ensure affordable access to broadband communications services for all schools. In determining how to make educational technology affordable, an approach to consider is that of the shared usage concept.

Can we achieve better focus for the educational technology work currently being done by the Federal Government?

Federal efforts in educational technology need to be better focused, and there is a great deal that can be done through civilian transfer of military education and training -- a real "peace dividend." But the potential involvement and contributions of the private sector cannot be overlooked, particularly when it comes to installing computers in the public schools. Ultimately, a nationwide private-public initiative, on a gigantic scale, would be required to assure that each of our nation's 15,300 school districts affordably and rapidly convert to 21st century learning requirements.

Mr. EHLERS. Thank you very much, Mr. Joseph.

And thank you again to the panel.

We'll now proceed with questions from the members present.

I happen to be first, simply because I reserved my time in the first round and I will just, I have one comment relating to the discussion we had in the first round, and actually I'd love to ask all these questions of everyone in all the panels. But you're the intermediate panel, and you're going to get the question.

But first I want to simply respond to a comment made during the previous one that the time horizons in Congress are two years. That is certainly not true.

Many of us have very long-range planning horizons. Supposedly Newt Gingrich's are half a millennium into the future. And many of us also engage in a great deal of futuristic thinking.

The two year planning horizon of course is an insult to the Congress because that implies we only look to the next election, and obviously we do politically but not in terms of policy.

It's unfortunately a myth perpetuated by the news media based upon campaign rhetoric, and I just wanted to set the record straight on that.

As far as questions are concerned, I've spent a good share of my life in education. I spent 22 years in the college classroom teaching physics. I also voluntarily, much to the surprise of my colleagues, elected to choose a course on science for future elementary school teachers. My colleagues regard that as the greatest self-punishment anyone could inflict upon themselves, and in some cases they were right.

But I was convinced the only way we could break the cycle of scientific illiteracy in this nation is to change the information base and the teaching techniques of the elementary school classroom teachers.

That was a great experience for me. I learned a great deal and I think my students did also.

But throughout that process, I became very, very impressed. I think there are two issues that are of fundamental importance to the success of any educational program.

One is the full-fledged interest and involvement of the parents, which I believe is the number one requirement for successful education.

And secondly, teachers who are given adequate materials and proper training to use the materials.

And when I think back on what used to be called "new math," and its limited success, I think in both points it failed, teachers, in any case, who were not adequately trained, and even worse, when the students went home with their homework and asked their parents to help them, the parents just sort of threw up their hands and said, this is stupid, I've never seen anything like this before. What is set-theory all about and what does that have to do with adding two plus two.

And at that point, the students immediately felt, well, of what value is this new math?

I'm very concerned about both of those aspects as it relates to our topic of today. I find many parents who just sit in wonderment and amazement at their children using computers and the standard re-

sponse is, "I'll never learn how to operate that, so that's the next generation, and we'll let them do it."

That's going to be very detrimental to the sort of things we're using, because what we're talking about here is much more than simply learning how to use the computer. We're talking about altering the way the instructional process works. We're talking about the emphasis on teaching children to think, teaching children how to learn.

And without proper involvement of the parents, that's not going to succeed very well.

As Mr. Joseph pointed out, we also have a tremendous teacher training problem. I am not, frankly, I'm not worried at all about wiring the classrooms. That's a technical problem, the industry's capable of doing it when the money is there, and that can be handled quite readily.

But training the teachers, giving them the background they need not just to handle a computer, but to deal with a totally new approach to learning, is a monumental task.

The Federal Government has a very limited role in this but it does have a role. And I would be interested in the responses of each of you as you take a look at what the Federal Government can do, but also just share your knowledge with the nation as to what you believe the elementary and secondary schools can do in terms of dealing with the training of parents and the training of teachers viz a viz the new educational approaches that are coming down the pike.

One other quick side comment. One of the problems of the schools is of course that society keeps giving schools tasks that are not educational in nature but are social programs of one sort or another.

I don't know the answer to that, but if you care, if you answer the first questions about parent training and teacher training and have time left over, feel free to address the broader question.

Mr. McCracken?

Mr. McCRACKEN. Teacher education in this area is very important. I think somewhere between ten and 20 of the states have something in their credentialing associated with technology.

About 50 percent of all teachers ever have used a computer of any kind and even that is very minor usage.

And the thing that bothers me the most is that current graduates of graduate schools of education throughout the country also immediately need to be retrained to prepare themselves for this environment.

There are just a couple of teacher credentialing agencies for the graduate schools of education in the country, and I think pressure can be applied there at a national level.

I think a national vision is appropriate, but I'm convinced that the answer is in the community. But there are inspired community leaders in every community in America that can put together the programs necessary to train parents, to train teachers, to get involved, to get business involved, local business involved.

And I agree that we're only talking about a very small percentage of educational spending. I believe the resources can be found locally to solve this problem.

But I think we need to give, at a national level, almost permission for these inspired leaders to put programs together.

So I think there is a national role in terms of vision.

I agree with the parents' issue when you have parents that can get involved—in fact, experiments have shown, places like Union City, New Jersey, that have put right up front a computer at home, the computer in teachers' homes, and then computers in the classroom, all networked together, that you get tremendous impact on the educational system.

In fact, in Union City, New Jersey, teacher absenteeism went from 17 percent to zero.

[Laughter.]

Mr. MCCRACKEN. So you can make a difference.

Mr. EHLERS. Thank you.

Mr. WRIGHT. Mr. Chairman, you raise a very critical point, and I think to address it, I think we have to again rethink the tools we're using in addressing the training dilemma that we're facing.

We've done several experiments along these lines in terms of how school districts go about this training issue today. And usually it's relocating professionals off-site, hiring substitute teachers to come in and so forth, which is an added expense to the organization to do the training.

In thinking about the tools and where they're located and the types of tools, I think we can rethink the way we deliver training and how it's delivered and how it's designed and organized.

And I think the same thing's true for parents.

We found that there generally are three questions that are asked in most American homes across the country when children come home from school in the evening.

What happened in class today?

What's tonight's homework?

And how can I help?

And it's very difficult to get good answers to those questions on a regular basis.

The good news is we're seeing a convergence of technology. It's becoming more and more difficult to discern our computer from your telephone, and as we move forward, your computer from your television set.

Access from home to that information at school in a seamless manner is certainly something we can look forward to in the not-too-distant future.

Assuming that those tools and the infrastructure to support that type of seamless conductivity can be brought into place, I think we are at a better position to address this huge issue of training. It is not only training, it is also support and maintenance.

Who is going to monitor these networks? Who is going to repair these machines if they are not functioning properly? That becomes more and more a critical issue as we think in terms of a critical mass of the appropriate tools at the classroom level and in the home.

So we have to think creatively along those lines.

But I think when we think about technology and the tools and type of infrastructure we are foreseeing, we are optimistic that

what appears to be a daunting problem in terms of training is perhaps less so if we could rethink the way we go about it.

Mr. EHLERS. Thank you, Mr. Wright.

Mr. Mendenhall.

Mr. MENDENHALL. Thank you.

I said earlier in my testimony that I think technology is the only option for real change in education.

One of the reasons I said that is that we all generally agree on elements of education reform. Namely: that teachers ought to become more instructional mentors and coaches; that students need to become more active learners; and that parents need to be more involved.

We have found the implementation of technology in the school enables those things to happen because it changes the basic structure of the teacher standing in front of the classroom of 30 students and addressing content, communicating content.

The minute you put five computers in the classroom, that teacher has a decision to make. Either they sit in the corner unused, which unfortunately is the decision in a lot of classrooms today, while the teacher delivers the lecture, or we restructure the classroom.

When we restructure the classroom, we typically will go put about ten students on five computers and they are working in pairs which are developing a lot of important other kinds of skills like teamwork, and collaboration, and team teaching.

A third of the group typically will be involved in independent kinds of study activities, hopefully structured.

And thirdly, the teacher will then be able to work with a third of the students in a smaller setting. We have just effectively reduced the class size, for example, from 30 to 10.

That does not happen automatically. It does not happen simply. The concept that we just put technology into the classroom and train teachers on technology and somehow they will figure out how to use it, how to change the classroom, how to restructure what they do, has proven over the last 15 years not to be true.

Most of the teacher in-service we have done for the last 15 years has focused on getting teachers comfortable with technology. We teach them DOS and WINDOWS and hard drives and floppy drives and RAM and ROM. In other words, we make them expert in computers.

The reason we talk a lot about teacher resistance is, no one ever relates it to what am I supposed to do with it to be a better teacher?

I think the training that we need to focus on for our teachers is. This is a tool that will make you a better teacher; that will enable you to do different things.

We find teachers that use the tool effectively in that way will never go back to the old way of teaching because they are now able to individualize and really help Johnny and Julie and really do what they entered the teaching profession to do.

I think the whole idea of teachers resisting technology is a myth. What they resist is being asked to learn a new profession, or a new technology that does not relate meaningfully to what it is they are trying to do.

Interestingly enough, in that restructured classroom there is now a meaningful role for the first time for a parent because, as you have a third of the students doing independent study in a classroom, we find parental volunteers almost always with those groups of individual students working with them, answering questions, mentoring them.

So parents are involved in the classroom.

I volunteer at my children's school. Volunteering at a school today means you drive on field trips, or bring do-nuts on the first day. That is not a meaningful environment. That does not encourage parental involvement.

Being able to come and be an aid in the classroom and interact with students doing projects and meaningful work, and being able to help them brings parents back and makes them interested in the process in schools.

Finally, you are absolutely right that parental involvement is the most important factor identified in educational success. Unfortunately, a number of our students in schools come from dysfunctional families, do not have parental support at home, sometimes through no fault of the parent who has to hold two jobs in order to support a family.

But our school structure has to compensate for that weakness as opposed to simply let those kids drop through the crack because we don't have the parental support which we need.

I don't think it's essential that parents learn how to use computers in order to provide that support. We find across the country that parents actually support computers overwhelmingly because they believe, perhaps more than any of us, that it is the one thing that can make a difference in schools.

So we've seen school districts where the last four bonds have been turned down unanimously, pass a bond for technology seven to one, because the parents feel that we're not just going to throw more money at the old system, technology can make a difference in schools.

So the children have the support. Parents are going out who can barely afford it and buying PCs and educational programs to give their children head start in schools.

They frankly do not have to know how to run it, they don't have to necessarily work it with their child. Their support is demonstrated by their financial commitment and by their working with the children at home to encourage them to do that.

So I'm very encouraged that parents will support it, are supporting it today. The key I think it that we train teachers properly to integrate it into their teaching, and again quite focusing on, gee, if we put computers out there, somehow they'll magically figure out how to transform education and students will magically want to learn, as opposed to playing nintendo games. Because there's no evidence that that will happen.

Mr. EHLERS. Thank you very much.

Mr. Joseph?

Mr. JOSEPH. I'd like to associate myself with Mr. Mendenhall's remarks. I agree with all of them.

But I think that a couple other points are relevant.

What I find absolutely amazing is a statistic in the August '95 issue of Curriculum Administrator Magazine, which is what professional K through 12 curriculum administrators read.

And as they survey their own peers, they discover that 36 percent of teachers are enthusiastic about using technology in the classroom.

Now on the one hand, you say, well, that means two-thirds of the teachers aren't, but I'm saying if a third of them are already enthusiastic and most of them have old Apple IIs, you know, what does that portend for the future.

Now the good news is that about six percent of teachers retire every year, so that other 60 percent who are predominantly older who don't want to change their ways, who have no incentive, who are tied to union contracts that tell them that they're only going to get a raise if the SAT scores go up, so there's no justification for doing anything but teaching SAT preparation, that six percent a year will roll over over the next ten years, and that's about the period of time it's going to take to really bring all these platforms into the schools in an affordable way.

Mr. EHLERS. Thank you very much. I appreciate those comments. I believe Mr. Sawyer is next on the list.

Mr. SAWYER. Thank you, Mr. Chairman.

I'm going to be able largely to pass. The question that I had planned to ask of our panel is precisely the question that you brought to them.

Let me just make a couple of observations before I have to leave. And that is that we talk a great deal about learning being as much a part of the work place as production or service itself in the immediate future. And yet the one place where we do less of that than any place else is among teachers themselves.

We talk about teacher training but we don't talk about the continuous professional development needed during a time of change. I think that's enormously important.

Mr. Joseph touched on a phenomenon that has been more or less smooth, that six percent turnover per year, but we are reaching a point right now where there is going to be a demographic phenomenon that parallels the baby boom—the retirement of teachers.

And that will mean two things. Number one, there'll be large numbers of people coming in right now and for the remainder of this century, and we will also rapidly lose the people needed to mentor them in conventional forms of teaching and learning in order to make an adaptation.

The whole question of modeling learning is perhaps the single most critical lesson that I took away from the last panel. I'm not sure that it does a lot of good to suggest that we ought to ask school boards to go out and hire teachers who think like children, however important that may be.

But rather that we build curricula and teacher training systems that teach teachers how to model learning.

And that's a more complex task. I'm not sure it's something that we do very well yet, but it is really part of the challenge of the future.

If anybody would like to comment on that, I'd be willing to hear it.

But I thank you, Mr. Chairman, and yield back.

Mr. EHLERS. Thank you. Very much appreciate that. Are there any comments?

Mr. Mendenhall?

Mr. MENDENHALL. I'd like to comment on that. This concept of modeling learning in the broadest, freest concept is simply, you know, there is technology in the classroom, they're working on projects, teachers are working on this. We find that unless that's structured in a meaningful way, I mean, the great teachers will do it and will model it and they'll do it whether or not there's technology in the classroom.

All of the other teachers need some structure around them, and I think the reformed classroom of technology is the classroom that focuses not on the teacher delivering content like some predetermined body of knowledge which everyone must know, but rather teaching the students to go acquire information, to use information, where to find information.

In the process of doing that, they're modeling the process of acquiring, using, finding information because the information you find this year is different than the information you found last year with your class. The textbook is no longer static, the content is no longer static. You're finding information and applying it to new situations.

And while it's challenging for teachers, that's exactly the challenge that makes their job more invigorating and more interesting to them, as opposed to the frustration that many of them have with the traditional job that they've had as teachers.

Mr. EHLERS. Thank you for that comment.

Dr. Bartlett?

Mr. BARTLETT. Thank you very much.

I've been very interested in the testimony.

I was privileged to spend 24 years of my life in the classroom, and so I've been sitting here thinking of all of those experiences and the role of technology.

The technology that you've been talking about of course is indispensable in the business world. If it's indispensable there, it needs to be indispensable in the classroom.

The technology is moving into the classroom, certainly not rapidly enough and not in enough classrooms, but it's there in a number of classrooms.

This technology ought to make learning easier. The students ought to know more. They ought to learn faster as a result of it.

But as you look at the achievement scores year by year, and I don't know if they've bottomed out yet, I've not been watching them this closely the last couple of years as previously, but for what, 30 years roughly, every year we gave quantitative tests to assess how we were doing in education.

In spite of spending more money on education, the scores of students were lower each year pretty much than they were the year before.

Clearly throwing money at education did not improve the scores. Technology ought to improve the scores, and I heard one of you say that there is study after study that shows that just moving comput-

ers into the classroom has not improved the scores of students who are in those classrooms.

Certainly we need to move this technology in because it's what they're going to be dealing with when they get out of the classroom and into the workplace.

But if the technology is not helping to improve the scores, and I heard, you know, we're using two words, training and education, it's training to know how to use this equipment. Hopefully, having been trained to use the equipment, you then can use it to educate.

What's happening in education that the increased money that we've been throwing at education, that the movement of technology into the classroom and it's not moving fast enough, but there is a meaningful amount of it there, why haven't educational achievement scores gone up, and what else do we need to do?

Mr. JOSEPH. I'll take a crack.

First, I believe SAT scores peaked in 1969 and went down consecutively every year until maybe the last one or two years, they've blipped up maybe a little bit.

Concurrently, in the same period of time, and I'm not saying this in a negative way, but the quality of people who have gone into teaching has continued to come from the bottom 20 percent of those who graduate from college.

Now this statistic was actually—and I shook my head when I first heard it—because I mentioned I testified here in '91, and it was Al Schenker who was sitting next to me at the time, who made the case that we need to get more technology in the classroom, because he had just seen the statistics of those students who just graduated high school in 1991, saying five years from now, from those who graduate college, from the bottom 20 percent of those graduates, we'll be putting our next math and science teachers into the classroom.

So we need the technology to supplement what they don't know. And so that's been a very big part of the equation too. Coupled with the fact that young people more and more find school not a very relevant place in the kind of world that they live in.

And in the previous panel, people used words like boredom, you know, whatever, but to go in and be told that what you're here for is basically to sit quietly for the next 12 years, while we prepare to you to take a standardized test that may or may not have anything to do with the future of your life is something they figure out early enough, that I don't know why I'm doing this, it makes no sense to me.

Mr. BARTLETT. Anyone else wish to comment?

Mr. MCCRACKEN. I just wanted to say that I've seen study after study that has shown where teachers have been trained and that technology is used intensively in the classroom, test scores do go up. I think the remark was when teacher training doesn't happen, then nothing happens.

Mr. BARTLETT. Thank you.

Mr. MENDENHALL. If I could just amplify a little bit on that. You've hit sort of my pet peeve or project. The fact of the matter is that in most cases, and by the way, we do have a lot of technology in schools. I think we are now with one computer for every nine children, and I suspect when we get to one for every five chil-

dren, we'll be at about the right level in terms of making meaningful impact in the classroom.

The difficulty is that most of those computers went in on technology plans that said, we want to get a computer for every five children, not we want to improve learning or we want to improve scores, or we're going to try to improve math in first grade, or reading in third grade, and they got what the planned. They got exactly what they expected, which was a computer for every five children.

Similarly, you know, we want to train our teachers to be comfortable with computers, not we want to train them to use them effectively in the classroom.

Most of the computers today are either being used in front of the classroom as a presentation device in place of an overhead projector or film strip, or they're down the hall in a lab being used either for computer literacy to teach kids about computers, as opposed to using computers to teach other things, or they're in the corner of the classroom being used largely for games at recess and lunch time and before and after school, either as a reward for being good or as remedial instruction for those who need additional help.

They have not, by and large, been integrated into the classroom, changed teaching, nor have they been focused on the applications which would make a fundamental difference in learning.

But as Mr. McCracken said, where they have been, and I've been selling technology to schools for 20 years, where it's been implemented by a school whose focus was, we're going to use technology to impact scores, we have gotten, as I said earlier, about a 20 to 30 percent improvement for three to four percent of the school budget.

Now that's on standardized test scores, and they are not a perfect measure of learning, but they're the best measure we have today.

I suspect if we had better measures, we might find greater increases in learning as opposed to smaller increases in learning.

So we know it does work. We also know it's not working in most cases. And I think we propagate that by talking and funding infrastructure. By talking about computer ratios in schools, by talking about wiring buildings, as opposed to talking about money for curriculum software, money for applications in the classroom, and money for teacher training.

Where we do that, we get good results.

Mr. EHLERS. Thank you all.

Mr. BARTLETT. Mr. Joseph mentioned that—

Mr. EHLERS. I'm sorry, Mr. Bartlett. The time has expired.

Mr. BARTLETT. Okay, thank you very much.

And I need to apologize that I can't stay longer.

Thank you very much.

Mr. EHLERS. With the previous panel, Chairman Walker announced that he would cut it off at a certain point, but those who hadn't asked questions would have preference during the remaining time.

The last person on that list is Ms. Morella, if you have any questions. And I think that—

Mrs. MORELLA. I shall be mercifully brief, Mr. Chairman.

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I very much appreciate the kind of expertise that you've given from the industry point of view with regard to the need for educating teachers, I think the next panel is going to be shedding some light on that too, as being critical.

I've also noted some newspaper articles. I represent Montgomery County, Maryland, which is pretty advanced in terms of—I think—terms of use of technology, and some of the articles have been focusing on the fact that the students have taken it within their own hands to do more, because they know more sometimes than the authorities in the schools. And they're impatient with regard to waiting.

And it points up sort of what you said that they recognize that it isn't so much money that's going to make the difference as it is moving ahead.

So they have self- help programs where they help each other. In one instance in one of the schools, they even did some wiring to facilitate getting on line.

So I think it's a whole new phenomenon where kids are faster than parents are, despite the fact that the parents are very well-educated, very successful and all, and I think it's a phenomenon that means that we've got to work harder with regard to teaching, including with parents.

One of the elementary schools in my community has a program where they train—the parents, the kids, the little kids in elementary school, it's almost like an even start, it's not called even start, but it's like an even start program—where the parents will come in and the children will teach them about not only what they're learning but teach them some new things with regard to the technology.

So that being said, if you want to comment on that.

But frankly what I'm going to ask you is what do you think can be done in terms of forging the appropriate partnerships between business and industry and the educational system, maybe other organizations too? What would you recommend be done in communities to facilitate technology as an educator?

Mr. EHLERS. Does someone wish to respond?

Mr. McCracken?

Mr. MCCRACKEN. I'd like to just talk about one example that I've been involved in for the last two years with an organization I co-chair called Joint Venture Silicon Valley.

Our group on education is made up of about ten business executives and about ten superintendents of schools and others involved in the educational process, including two school teachers, one at the high school level and one at the elementary level.

This is the $20 million that came out of business is funding this group, which is then funding projects in education.

We found in surveying business in silicon valley that business felt that the educational system in silicon valley was the number one detriment to the economic future of the valley, more so than transportation and a lot of the other issues that we face from day to day.

So it's actually been quite easy to attract business interests.

What we found out of the educational institutions was a sense of apathy that things can't be changed. Just by doing this together,

I think we've already started to turn the apathy around and started to develop some hope for the future.

So again I think it's community action, I think it's bringing people together at the community level from both groups. It took us about a year just to learn the same words and that the same words, develop an environment where the same words had the same meaning.

So we actually waited about a year to develop a good communications ability between ourselves before we started funding the program.

Mrs. MORELLA. Well, who instigated it, Mr. McCracken?

Mr. MCCRACKEN. Well, it was instigated by open community hearings about what the priorities were in the valley.

Mr. EHLERS. Thank you very much.

Mrs. MORELLA. Could we hear from each of the others quickly? I mean, just—

Mr. WRIGHT. I would just echo Mr. McCracken's statement there. I think in most communities, you'll find that the business community is, when they are regarded as a stakeholder in the process, is more than willing to participate. And I think coming to the table of the education community, the business community, parents and so forth on a common agenda is absolutely critically important. In the research sites we are working with we are finding that the business district as well as the school district, when a common agenda is established, is more than willing to collaborate.

Mr. EHLERS. Any other quick responses?

Mr. Mendenhall?

Mr. MENDENHALL. I think the single most important thing business can do to support change in schools is to insist on results; to set standards; to insist on achievement; to insist on some measurable change.

Too often when a school district talks about buying computers, the questions are.

What is the price?

How much will it cost?

Not, what do you expect to accomplish with these machines? If business will be clear about their requirements and hold schools to high standards and insist on improving results for money spent, as we insist on in our own businesses on a return on investment, then we will be able to bring about real change by focusing on the key issue, which is changing learning outcomes.

Mr. EHLERS. Mr. Joseph?

Mr. JOSEPH. Quickly, I agree with the accountability standards, too. But also, as I mentioned earlier, now that Chairman Goodling is here, we have to ramp up the level of the involvement. We have to, instead of picking on developing—while you have community-by-community programs, it has to be in the context of your game plan, as in the Pennsylvania example I gave of Penn State working with the State Chamber, working with all the State major players and laying out the framework that works statewide, and that puts the other groups in place and then you can accelerate a combined, unified vision that works for everyone in terms of bringing technology into the learning process.

Mr. EHLERS. Thank you, very much. The lady's time has expired.

The remaining names, just to clarify the list, we have Ms. Johnson next, followed by Mr. Cunningham, Ms. Woolsey, and Mr. Fawell.

Again, since in fairness we want to allow time for the next panel, we would encourage everyone to keep their questions and responses brief, but I certainly do not want to cut anyone off.

Ms. Johnson, do you have any questions?

Ms. JOHNSON. Just a brief comment.

I want to express the appreciation to the private industry for the support that education has received.

Being from Dallas, Texas, where we have a variety of technologies, they have been very, very supportive and we would continue to encourage that. Sometimes that is the only way we get introduced to the various technologies is through our private industry who is willing to furnish technology for a limited period of time, or whatever, and that is appreciated. It really shows a real partnership from private industry to our public and private schools.

I hope we will continue. I am attempting also to try to encourage our teachers and our leadership in our schools to embrace that even more.

So, thank you.

Mr. EHLERS. Thank you, very much.

Mr. Cunningham?

Mr. CUNNINGHAM. Thank you, Mr. Chairman.

I talked to Del Corning and asked him, what kind of an investment can we really make into the systems? They told me—and I got these figures secondhand, so I do not know if they are accurate or not, but they said about 3 percent of copper wire becomes obsolescent each year. So we can invest in new fiber optics.

He said we have about a 3 percent increase in new facilities, in schools and libraries. So there is about a 6 percent investment, I truly believe that we can make, on a federal, state, and private level.

My real concern—and you addressed it a little bit in your talk, is what we call the "consummables." We talked a little bit about it during the break, that I can buy a computer today but in six months I may not be able to talk to the same company's computer either with software or the new systems from a 486 to a new system, or whatever.

Then when we have different school districts, some use an IBM, some use an Apple, some use the others. How do we tie that together to be able to talk?

I think, first of all, is it our problem, as we get only 7 percent of education dollars out of the Federal Government? 93 percent comes from the state.

I think until we change the entire role of what government looks to as education, in this Member's opinion, we need to change the whole way that this Committee views its responsibility to education. I think we can take 7 percent of the dollars, but we can get more than 23 cents out of each dollar down into the classroom by the research and the development and the high tech investment. I think we do more that way than we do with the social engineering that we try and do in this committee as it is today.

But at the same time, if we do that too fast with education being forward-funded, I eventually want to take most of education back to the states. But I can't do that right now because I have got forward-funding and I am going to hurt the very things that you are trying to correct.

I agree with my democratic colleagues. I think in the Republican Party we are doing it too fast. The real question is. How do we solve, other than just leasing the equipment for a school system to invest in computers and software, how do we get that regenerating cost? Because the school system does not make any money from it.

Mr. EHLERS. Any volunteers to respond?

Mr. MCCRACKEN. I have two quick responses.

One is, the technologies—we are the right time, from a technology standpoint. The idea of the Internet and the World Wide Web that we already about allows essentially all computers to work together, to talk together, and access information that is available over the Net.

That may not be true of computers that were produced five or ten years ago, but certainly it is true today and into the future.

I think that is one of the things that is causing an explosion and interest at the present time.

On the consummable side, the McKinsey Report I referred to earlier that is coming out in about a month, developed a cost model, including teacher education, of about 4 percent maximum on an ongoing basis—4 percent of the total budget over the year.

Assume that the—

Mr. EHLERS. Is that state and Federal?

Mr. MCCRACKEN. That is total education spending—community state, federal. About 4 percent of that would be the maximum ever needed, and that included a replenishing of the systems, replacing the systems with new technology on a periodic basis, generally in less than five years.

Mr. EHLERS. I might just interject that that is considerably less than the health care costs. The school systems pay.

Mr. Wright, did you wish to comment?

Mr. WRIGHT. I would follow up on Mr. McCracken's comment and really emphasize that our own independent studies would tend to agree with the McKenzie report that about 4 to 5 percent is what is required, if in fact all of the components are delivered simultaneously—the right tools with the right training with the right support, and so forth.

The idea of redirecting existing dollars becomes more and more reality. With the extensive video networks throughout a school district, fewer bus rolls are needed to participate in event-sharing.

With access to electronic data bases and so forth, schools are going to be less willing to spend $40 per child on a textbook that is delivered brand new with information that is seven years out of date.

So we are seeing with the right tools, the right access, and with a continuing improvement in the software and the electronic information that is available, for the first time ever being on the verge of redirecting substantial dollars.

Mr. EHLERS. Mr. Mendenhall?

Mr. MENDENHALL. First of all, we would agree with the general percent that about 4 percent of the school budget does allow for the implementation of technology and the applications and the training to make it effective in school. That assumes a turnover about every five years of computers.

Too much is made of this computer obsolescence. Again, because the focus is on the hardware as opposed to the application. If in fact you buy something that teaches math well, frankly the math we have taught has not changed in the last 50 years, and it will teach math well five years from now.

It will no longer be the fastest, fanciest computer, but it will be perfectly adequate for the application for which you bought it.

In terms of Federal funding, while it is only 7 percent, first of all today a disproportionate amount of it compared to the general amount is spent on technology. That is, overall we spend about 1.3 percent of the education budget in this country on technology.

Four to five percent of Federal funding today is spent on technology.

Where the Federal Government I think can help is to focus even more of its 7 percent on technology. I think the rest of it fundamentally is supporting the status quo, the existing system that we have poured money into for 20 years without getting additional results.

Secondly, the Federal Government can take a leadership role in focusing that money not just on infrastructure but in making money available for applications and training as well to point the way for other spending in states and in localities.

Mr. CUNNINGHAM. Would you agree that if we just eliminated the bureaucracy, instead of the 23 cents we could more than double that investment into technology?

Mr. EHLERS. Mr. Joseph, did you wish to respond?

Ms. JOSEPH. Just quickly to the original question.

The interoperability problem is something that can be solved with the right kind of add-ons to computers if they are at least 386s, and that we can network them together into something that will work in a relatively efficient fashion.

However, I think we have to keep in sight of what we are really thinking about.

The question is not "How does every school district afford to keep up with it?" Because digital information is the fuel for the 21st Century, and we would not have sat around 100 years ago saying how will every school system afford to have its own electric power plant?

Or, how does every school system afford to have its own phone company?

Or, City Hall thinking about how do we set up our own power plant and our own phone company, and so on and so forth, which goes to the broader plan community-wide of setting up community digital utilities, if you will, that share in continuously upgrading the technology platform they all share from.

This is the idea that the World Bank is looking to fund in various parts of the world because they have to start with a system that everyone shares in, because they just do not have the infrastructure that allows everyone to have the luxury of their own thing.

Mr. EHLERS. Thank you very much.

The gentleman's time has expired.

Ms. Woolsey?

Ms. WOOLSEY. Thank you, Mr. Chairman.

Mr. Chairman and Chairman Goodling, I have a recommendation—thank you for these great hearings today.

I think we should start a bipartisan joint committee task force now to start working on technology in education. We should not have the Democrats going in one direction and the Republicans going in another. We don't want to come up with good ideas and find that we are both suspect of each other. Let us start working on this together.

We have to get into the information age, and we have to do it in a bipartisan fashion. So I recommend a joint task force.

I was pleased to hear that good parents do not have to be computer literate. I hope this means that good Members of Congress do not have to be particularly computer literate, because this is a really low-tech place.

I hope you know that, when we are sitting here making all these decisions.

My daughter actually, speaking of getting wired, works for Wired Magazine. So of course my office is on the Internet, and we are soon to be on the WEB, but our computer system is generations behind what it could be—and it was most-current at the time that I bought it.

It is almost impossible to afford to update it. So that is who you are working with. I mean, you are working with a low-tech Congress making high-tech decisions.

So I am going to tell you what I think. I do not think we should be the ones that are leading this charge. I truly—and you are the industrial panel here—I believe that business and industry ought to be leading this debate, and I think you ought to be carrying a large part of the responsibility and the burden.

I think the Federal Government should provide incentives, but you are the stakeholders, you have to have a work force for the information age. You have to have new workers. You have to have retrained workers. You have more at stake than any other interest group in this country, except that the Nation in general should care a lot about the whole issue.

So I think that it is going to be up to you—and you can respond to this—to educate the rest of the public and lead the communications about how important technology is to the future of this country; how certain it is that we are all going to be relying on technology all the time.

The taxpayers do not understand this. It is going to have to come from the people who work with you, the people who work for you, and the people you are hiring.

I challenge you. We have got equipment. We have got infrastructure. We have got installation and maintenance. We have got training for the teachers and for the kids. And then we have to have employment when it is all over with.

I think it really rests a lot on industry.

So, if you would like to respond to that, I will listen.

Mr. EHLERS. For responses why don't we start from the other end, for a change.

Mr. Joseph, you have the first word this time.

Mr. JOSEPH. The local Chambers of Commerce are sort of in an interesting situation these days. We took a number of the key chamber people from around the country who were at the cutting edge of working with their communities to really advance education and training.

One of the people from an unnamed city said, you know, ten years ago companies wanted to maybe come to our part of the country.

We would just lie to them. We would say, oh, it is great. We've got great schools. We've got great churches. We've got great communities. It is wonderful. Come on down. This is a fabulous place—whether we had the facts on our side or not.

He says, we cannot do that any more, he says, because industry knows exactly what our schools are producing before they even show up here.

It is a global world, and literally this person went through the scenario of a major company said we are either going to go to your community or we are going to go to Mexico.

Now in Mexico we know the labor is going to be a whole bunch less. But we prefer being here if you guys can show us that you have got the community-wide commitment to put in place the school systems so that we know after we build this $40 million factory that it is going to take us 20 or 30 years to amortize, that the people who come through your school systems for the next 20 or 30 years are going to be qualified to work there; and that you will also rejigger a community college system so that we can have retraining opportunities as we adapt with what we are doing.

That community did that, and they won out over Mexico. That is the model we are showing Chambers all around the country that you guys at the local Chamber community level have to be in the forefront of doing these things, of leading the charge; otherwise, that community is not going to be there. There is not going to be an industry.

Mr. EHLERS. Does anyone else wish to respond?

Mr. Mendenhall?

Mr. MENDENHALL. I think the support for change in our schools, and reform in schools, and specifically reforms through technology, needs to come from all levels and sectors of society, from federal government, and state government, and localities, and certainly from businesses.

First of all, we do not need, in my opinion, from the Federal Government development of applications, nor do we need research particularly on what works.

There is ample evidence of what works. There are good applications available. And if there is a focus on results, and if there is funding for applications and results, then private industry will rise to doing the development and creating the applications and providing the teacher training in order to generate those results—if the results are valued and if funding is available for those results.

We are, as IBM, you may know our Chairman, Lou Gershner and Thompson of Wisconsin are hosting a Governors' Conference in

March for all of the Governors, a one-day conference on technology in education specifically, because we think the states have a big role to play in technology.

We spend millions of dollars each year on developing applications for schools, specifically to improve performance in schools.

We have given away this year over $20 million in individual grants to schools for innovative projects using technology to reform educational institutions.

I think business can and will step up and play a bigger and bigger role because it is essential to our work force. But we need support from the Federal Government, the state government, from localities, from parents, from all sectors of society that education is a priority and that technology is the key to implementing that priority.

Mr. EHLERS. Thank you.

Mr. Wright?

Mr. WRIGHT. Yes. I would echo those comments.

I would add to that that, just from a practical matter, the figures that have been shared today about the cost to do what we are talking about doing are daunting. Simply from a practical matter, schools cannot do it alone.

We are going to have to think creatively about how business and the private sector work together, and we are going to think about how best to bring that about, whether incentives to do that are more appropriate in some cases than mandates both from the business side as well as on the public school side.

But you are right. The agenda for all parties is too great to ignore. I am optimistic that that collaboration will continue.

Mr. EHLERS. Mr. McCracken, do you wish to add anything?

Mr. MCCRACKEN. Two quick comments.

Relative to an educated work force, I was walking through our manufacturing area in Silicon Valley recently and it struck me that—and I have since studied it—that about a third of our very high-paid manufacturing workers are first-generation Americans.

I suspect that one of the reasons for that is that their K through 12 education was a lot better and they can handle the statistics and understanding of our manufacturing activity.

We do manufacture in the U.S., but the first-generation Americans are having a tremendous impact on that.

We accept the challenge, but we would like you with us both at the national level and within your own districts where I think you can also make a major difference.

Ms. WOOLSEY. Thank you.

Mr. EHLERS. Thank you very much.

The lady's time has expired.

I would just make one comment. As Chair of the Computer and Information Resources Working Group of the House Oversight Committee, we hope you will have a high-tech Congress very, very shortly, within a year or two, and a very well-trained Congress, as well.

Last, but—well, not necessarily "last." Mr. Fawell, do you have any questions?

Mr. FAWELL. Mr. Chairman, I am going to save my questions for the next panel.

Mr. EHLERS. Pardon?

Mr. FAWELL. I am going to save my questions for the next panel.

Mr. EHLERS. Fine. Mr. Fawell reserves his time.

Mr. Goodling?

Chairman GOODLING. I have nothing.

Mr. EHLERS. Mr. Goodling has no questions for this panel. Thank you again for your attendance here and your words of wisdom. We really appreciate them, and the record of course will encapsulate all your comments, as well.

I would like to call for the next panel to come forward, and also mention that Mr. Goodling, who is Chair of the Economic and Educational Opportunities Committee, which is co-sponsoring this, will assume the Chair at this point. I think it is entirely appropriate that he be the one chairing the section on the educational panel.

The panel will consist of Dr. Deborah McGriff, Senior Vice President, the Edison Project, New York; Ms. Cheryl Lemke, Associate Superintendent, Illinois State Board of Education; and Dr. Alan Brown, Superintendent of Waukegan Public Schools in Illinois.

We will start with you, Ms. McGriff, and I will turn the Chair over to Mr. Goodling.

STATEMENT OF DR. DEBORAH McGRIFF, SENIOR VICE PRESIDENT PUBLIC SCHOOL PARTNERSHIP, EDISON PROJECT, NEW YORK, NEW YORK

Dr. MCGRIFF. Mr. Chairman, Committee Members:

I am Deborah McGriff, Senior Vice President of the Edison Project, a private company that partners with public school districts and charter schools to provide world-class education for all students.

I want to thank you for the opportunity to talk to you this afternoon about education in the 21st Century.

I would like to begin by describing our vision of education in the year 2015, and then describe how we get to that 21st Century vision.

I would like each of you to picture an invention that we would call "PAL." PAL is personalized technology that students, teachers, and adult learners carry with them everywhere.

Learners use their PAL to plug into the information highway that runs through their community. They are connected to museums, libraries, community, industry, and government archives.

This connection has a tremendous impact on learning.

How might learners use their PAL?

A teacher is at home in Boston planning for her students. She could use her PAL to access a national database of exemplary lessons and resources.

A youngster learning about the Constitution could use his or her PAL's filtering mechanism to access a database for only those resources that teachers, parents, and the community deem appropriate for his or her developmental level.

College students in that community could use the same tool to take on Hamilton and Madison on their own terms using the imaging and historical retrieval potential of technology.

PAL makes lifelong learning an affordable reality any place, any time, anywhere. No longer would learners rely on what educators

call "pull-out programs" where learning occurs in isolated classrooms, workshops, or seminars, whether the learner is a teacher, or a student, or a professional in industry, or an adult seeking a GED, just-in-time learning would be the norm.

New models of teaching would develop. We would move beyond what everyone has described today as the teaching by telling model, and the learning by listening model of education, so that we would be able to reach different students, teach different skills, and achieve multiple goals.

Now how would we accomplish this vision by 2015?

We need at least four basic principles to proceed.

One, we must develop ubiquitous infrastructure.

Two, there must be an availability of rich content and resources.

Three, there must be the ability to personalize access or, what marketing people like to call, mass customerization.

And finally, equality of access to the infrastructure and resources.

Let's talk a little bit about the first cornerstone. I agree with many of the previous speakers that this is the easiest to establish, but in many communities they will require additional support—especially from the Federal Government—so that communities and school districts and charter schools whose per-pupil allocation is currently below the national average will have the ability to access these resources.

If that is done, we have the ability to narrow the gap between the haves- and the have-nots.

While laying the wires and cables is the easiest step to take, in the end it is the least important aspect of reforming learning through technology. Far more important than investing in infrastructure is making sure that something different and meaningful happens with that capital investment.

The question that we must continuously ask ourselves is what, after all, is the purpose of all of this technology?

We must look beyond the technology infrastructure to the educational goals and the human and organizational issues involved in developing new models of teaching and learning.

We have spent considerable time today talking about the need for additional teacher-professional development, and I would like to speak a little about that, as well.

Every teacher education program must require new teachers to master not basic technical literacy but rather the methodologies of teaching with technology.

We must end the practice of computer teaching teachers and encourage instead computer using teachers who use diverse technologies to support their practice.

Ongoing re-education has also been emphasized today. That is why in the Edison Project teachers are given two hours every day to plan and assess their professional activities.

There also was expressed a need to have some structure to this re-education and professional development. In our schools it is our expectations that during the first year teachers become comfortable with the technology. During the second year they develop a level of confidence. And by the third year they move to a level of creativity.

But equally critical as the task of preparing teachers is the task of preparing communities. Communities must redefine their educational goals and place technology within that context.

The Challenge Technology Grants we consider an excellent example of communities working together to implement technology.

My final recommendation relates to another feature of Edison Schools. That is, providing a computer for every student's home that is linked through local and wide-area networks to the schools and their teachers.

We believe that homes, computers, and home learning are another critical element of equity and believe that that must be included in any transformation of technology and learning in the 21st Century.

Thank you.

[The prepared statement of Dr. McGriff follows:]

Testimony by

Deborah M. McGriff, Ph.D.
Senior Vice President
The Edison Project

for the

Committee on Science and Economic
and Educational Opportunities
United States House of Representatives

Joint Hearing
"Educational Technology for the 21st Century"

October 12, 1995

Thank you for the invitation to talk about education in the 21st Century. I'll begin by painting a vision of the future. Then I'll describe how we get to the 21st Century vision

Picture an invention that we'll call PAL. PAL is a personalized technology that students, teachers, and adult learners carry everywhere: home, school and work. Learners use their PAL to "plug in" to the information highway that runs through their community. The wealth of resources available to learners is extraordinary: museum, library, community, industry, and government archives of unimaginable richness. The educational results are amazing.

A teacher at home in Boston, planning for her students, could use the PAL to access a national database of exemplary lessons and resources in any subject.

Similarly, a young child learning about the Constitution, unready to confront the rigor of the Federalist papers or other primary sources, could benefit from PAL's filtering mechanisms to search the database for only those resources that teachers, parents and the community deem appropriate for his or her developmental level. College students could use the same tool to take on Hamilton and Madison on their own terms, using the imaging and historical retrieval potential of the technology.

With tools such as PAL, life-long learning would be an affordable reality anyplace, anytime, anywhere No longer would learners rely on what we educators call "pull-out" programs, where learning occurs in isolated classrooms, workshops, or seminars. Whether the learner is a teacher or a student, a professional in industry, or an adult seeking a GED, just-in-time learning would be the norm

This availability of and personalized access to resources allow new models of teaching to develop. Team work, projects, interdisciplinary explorations, alternative means of assessment: all of these approaches are alternatives to the traditional model of direct instruction in separate subjects. Moving beyond the teaching-by-telling and the learning-by-listening model of education enables us to reach different students, teach different skills, achieve multiple goals. Without technology, these alternative pedagogical models are, if not impossible, at best extremely difficult for any but the most gifted and energetic teachers to implement.

I've just given you a vision of education in the 21st Century Let's step back now and evaluate what we need to do to achieve this vision by the year 2015.

First, we need to agree that four cornerstones support this vision of learning: ubiquitous infrastructure; availability of rich content and resources; the ability to personalize access, or what marketing people like to call "mass customization"; and finally, equality of access to the infrastructure and resources.

The first cornerstone will be laying the wires, establishing broad band communications services, and digitizing our rich national archives. Schools, libraries, and community centers, as the educational foci of their communities, require access to these services. Yet many of our institutions need

assistance with both capital and operational costs. The federal government should take the lead in providing funding to communities, including school districts and charter schools whose per-pupil allocation is far below the national average, to enable them to contract with educational service providers such as The Edison Project. Through universal service we can narrow the gap between the haves and the have-nots of our nation.

Laying these cornerstones, with proper federal and state support, will form the foundation for a new vision of learning. But laying the wires and cables to connect our educational institutions to the information superhighway, while the easiest to grasp, is in the end the least important aspect of reforming learning through technology.

Far more important than investing in infrastructure is making sure that something different and meaningful happens with that capital investment. The question we must ask ourselves is what, after all, is the purpose of all this technology? We must look beyond the technology infrastructure to the educational goals and the human and organizational issues involved in developing new models of teaching and learning. Let's begin by tackling the issue of teacher training, particularly in colleges of education.

Every teacher credential program should require new teachers to master not basic technical literacy but rather the methodologies of teaching with technology, regardless of discipline. We must end the practice of computer teaching teachers, and encourage instead computer using teachers who use diverse technologies to support their curricula.

Equally critical as the task of preparing teachers is the task of preparing our communities for these new technologies and these new visions of education. Communities must redefine their educational goals, and place technology within the context of that redefinition.

Much like the Challenge technology grants which urge consortiums to work together to implement technology, the Edison model of public-private partnership relies on integrating all the resources of a community. It creates an empowered group of parents, teachers, students, and community leaders all using the school as the focal point for their access to the immense resources that technology will make available to them

Thus at Edison we provide a computer for every students' home, linked through local- and wide-area networks to the school and to the teachers and administrators. Using our exclusive telecommunications network, teachers, students, and parents can interact on a daily basis, if necessary, with the ease of e-mail This allows families to be more intimately involved in their children's education

In these days of family values, we at Edison believe that technology should reinforce these values. The wires and cables that bind the Information Age together will also bind families and communities together as people talk, argue, collaborate, and create in an effort to bring the best out of our young minds, and to create the workers and citizenry capable of bringing a strong America into the 21st Century.

Chairman GOODLING. Thank you.
Ms. Lemke?

STATEMENT OF MS. CHERYL LEMKE, ASSOCIATE SUPERINTENDENT, LEARNING TECHNOLOGIES, ILLINOIS STATE BOARD OF EDUCATION, SPRINGFIELD, ILLINOIS

Ms. LEMKE. Thank you.

It is a distinct honor to come before you and talk about this very important issue which is really a basis for the economic growth and health of this Nation.

We have heard some speakers in the past talk about the future, and I would like to share my views on that.

One of the things I think we are seeing is that there is a recognition that there is a significant change in the society at whole; that indeed we are looking at a global telecommunications network that links the world. We are looking at a global economy. We are looking at alliances that are very different, and we see that in everything from the changes in the industry like IBM, et cetera, and we see an empowerment of the individual, where people really do have that empowerment—whether you see it in Talk Radio, or you see it on people who are actually on the Net interacting in ways that have never been possible before.

There is true empowerment of the individual.

What that means for education is that we need a very different kind of system, and very different goals, if you will, in the system. That is kind of what we are working through in that transition at this point in time.

So what does that system look like?

One is that it has to be very student-centered. The whole idea that for so long our system has been very adult-oriented, and it's time for us to get away from that and focus on the individual children that we're dealing with.

And that means that we connect kids with community; that when we have learning activities that they're real activities that impact real people.

Let me give you an example from the state that I've recently moved from, Washington State. We decided that the way that social studies teachers were teaching state government was not doing a very good job. It's a very dry, boring subject in most schools.

So what we did was we connected classrooms with state legislators across Internet. We connected kids to electric access to bill updates on a daily basis during session. We had hearings such as this across interactive video conferencing where kids across the state could study that, could poll their communities and get impact. They influenced public policy. It was real. And that is the kind of activity that we are really looking for.

We feel like the multi-age approach is good.

We think the empowerment of the individual to live anywhere will make a real difference. Right now we have 11 million people in the United States who are telecommuting. That is a tremendous number, and it is growing.

That means people can pick up their computers and FAX modems and phones and go literally anywhere in the country. This

could be an opportunity for economic development in our rural and remote areas, and our education system has to be up today.

We need affordable access for citizens and for students. We not only need the access, but we also need for those people to have the knowledge and understanding to be able to use that access. Because it is one thing to get access to information; it is quite another to turn it into knowledge and understanding and wisdom.

We need the telecommunications infrastructure everywhere. We have an opportunity right now with the telecommunications' regulatory issues that are before you and the rewrite of the Telecommunications Act of 1934. It really is an opportunity for us to take a look at what is going on to make sure that education and health facilities and libraries have access, affordable access.

This is a window of opportunity. We are building the base for economic viability for many of those companies for years to come. It is time to look at some trade-offs to make sure that they help us build that base.

We need extensive training, and we need education as we go through this whole issue. We need seamless digital libraries so kids really do have access to primary source data. So instead of just looking at things and saying, oh, this is somebody's interpretation, these children and these youth can go directly to the source, to source information, and be able to analyze, hypothesize, synthesize, and then turn that back so that the World Wide Web is indeed a way that they can publish for the world.

An example of what we are trying to do in Illinois is we are connecting with museums where children across the State of Illinois will actually work with the museums in Chicago and other areas to digitize imagery, do research behind the artifacts, and put a kid's spin to those artifacts and put them on the WorldWide Web and make those artifacts available to everybody in the world.

It is a powerful kind of approach, and kids really are engaged in doing this. That is what we are doing. we are turning those kids on and getting that glazed look off their faces.

[Laughter.]

Ms. LEMKE. I think it is a real criti l one, and one that we need to continue.

This means that we have new roles for students and new roles for teachers. For so long—someone told a joke the other day that said that if aliens came down and looked at the system in many classrooms today, what they would say is it is a place where little people come to watch big people work.

I think we need to change that. We have a system where we can empower these children to be a part of the system, where we can engage them in real projects, and we really need to go forth with that whole issue.

I do have some recommendations for you.

One is that our public does not understand this issue. We need a public awareness campaign so that visibility comes up because frankly what we are seeing in a lot of places is that support and dollars follow vision.

Let me give you an example:

One of the communities I have been working with is a little community called Onalaska in southwest Washington, a logging com-

munity. They are very economically depressed. Many of those people are out of jobs. And yet that system has fiber access to every building, every child, and every youth; has an Internet access account; parents can, if they want. All teachers are using technology very effectively.

When you ask the superintendent. How did this happen in this community that is so economically depressed? His response is that these people understand firsthand what it is not to have 21st Century skills, and they do not want that to happen to their children.

So they are willing to put their dollars into making that happen.

I think a theme that is happened throughout today is that we cannot do this alone; it has to be through communities, through a cooperative venture; and I think all of our communities are up to it.

I think the challenge grant that went out from the U.S. Department of Ed was exemplary in this form. They insisted that partnerships happen. Applicants could not apply unless they had a variety of partners in this.

I think that is a real positive move, and I would encourage Congress to continue with that.

A second one is the whole community focus and the idea that you have got a lot of disparate kinds of grant opportunities that you could bring together so that communities can really look at this from a comprehensive point of view; that they are not only building the infrastructure, but they are also moving in directions where we have a trained and sustainable work force to bring this about.

We need flexibility.

I really frankly was appalled at some of the things the first panel member said about the current education system. I believe in many of the things they talked about. that we need student-centered approaches; we need kids who are engaged; but I think we can do that from within the system.

Frankly, if you look around the Nation, you will see extraordinary things happening within the existing system. What we need to do is to make sure that people such as yourselves go back into your particular communities, find those pioneers, and honor them because they deserve it, and use them as models to move forward and provide the flexibility for those schools systems so we can really do that in a variety of places.

My personal understanding of how change happens is that it does not happen through mandate. It happens through incentives. It happens through system building and system capacity building. And it happens by empowering individuals.

If you go into a school building, and instead of just saying thou shalt, that you actually bring them together in a systemic strategic planning process so that we are all moving toward the same vision.

You give them the facilities and resources to do that, and you do the staff development in new ways. So instead of saying you are going to travel over here to the next county on Friday night and Saturday and learn some new things that have nothing to do with your kids, what you should be doing is bringing that staff development into that school that is very appropriate for their kids, their curriculum, their instruction, their machine, their software and hardware.

If you do that, then you have got something that is involving children as they go along so they see the impact of what they are trying to do, and they are interacting with kids.

The last one that I would like to talk about is infrastructure. I think that is a real critical one. It is probably the easiest one, but at this point in time it is a real barrier for many schools.

Let me give you an example of the State of Illinois. We have school buildings who actually spend as little as $3000 per children—per child, rather, and we have schools that actually spend as much as $14,000.

There is great inequities in the state, and I think we are not alone.

That presents great barriers when we are trying to build an infrastructure where we have equitable universal access to this for all children.

I believe that the panelists before us were really right that we need a comprehensive approach to that. We need every school wired, and every child having access to this information.

So I would like to end by defining "education," if you will, or actually defining "learning" based on a definition from one of my friends in British Columbia.

She calls "learning" the history of significant moments in the child's life.

I think it is the charge to educators and communities and business and industry to make sure that those significant moments happen in children's lives and we go forward with that.

So thank you very much.

[The prepared statement of Ms. Lemke follows:]

Testimony for the Joint Hearing between
the Science Committee and the
Economic and Educational Opportunities Committee

Educational Technology in the 21st Century

October 12, 1995 Testimony
by Cheryl Lemke, Associate Superintendent
Illinois State Board of Education

Chairmen Walker, Chairman Goodling, Members of the Science Committee and Members of the Economic and Education Opportunities Committee, it is a distinct honor to come before you to testify on the topic of Educational Technology in the 21st Century. On behalf of the Illinois State Board of Education, State Superintendent Joseph Spagnolo and education practitioners across the nation, I applaud your recognition of the critical importance of this issue to the future of this nation.

Background:
John Naisbitt, in his book, Global Paradox, states, "In the global economic network of the 21st century, information technology will drive change just as surely as manufacturing drove change in the industrial age." And that change includes education, for just as yesterday's schools were based on an industrial model, tomorrow's must be based on an information and communication model.

Naisbitt goes on to say, "Information is power, but unlike earlier times, concentrating information in the hands of a few is no longer possible. That makes life, commerce, and economics even more complex than most of us can possibly imagine."

Examples of this phenomenon abound. Whether it is Tiananamen Square, the Berlin Wall coming down or the atrocities in Bosnia, information is being shared across the globe by everyday citizens who have access to these new communication tools... and the world is listening and reacting. With desktop publishing, personal computers with modems, the internet, and talk radio, a citizen today has all the tools necessary to personally impact public policy in ways never before imagined. Technology and telecommunications systems have empowered the individual to think locally, but act globally.

Today educators and policymakers across the country are asking what it means to be a learner in this age of communication and technology. Eric Hoffer shares his insight, "In times of change, learners inherit the earth, while the learned find themselves beautifully equipped to deal with a world that no longer exists."

The students of today need 21st century tools if they are to successfully live, learn and work in this global, technological society. To bring relevancy, motivation and quality to the learning environment, those 21st century tools must be the infrastructure upon which a sound education is built. Never before have the challenges and opportunities in education been greater or more pivotal to the health and growth of this nation.

There is a critical need to realign K-12 education to the realities of the 90's and beyond, to realize the opportunity to use the tools of the 90's to dramatically improve the system for all children and youth.

A Redefinition of a Quality Education

The invitation to testify here today referenced an interest in considering the future of K-12 education twenty years hence. Given today's trends of: an emerging seamless network of telecommunications global systems, the formation of alliances of telecommunications enterprises due to the digitization of data, and the resulting empowerment of the individual, it is reasonable to assume a need to realign K-12 education to the realities of the 90's and beyond.

Inherent in this redefinition of education is a careful consideration of what a "quality education" means for this new era. Given the end of communism, the single market world economy, the spread of democracy in the world today and the revolution in telecommunications, a quality education means an empowerment of the individual to live, learn and work as a functioning member of both local and global communities, maintaining the integrity and distinctiveness of the local, while effectively interacting with, competing in and contributing to the global.

Given these trends, it is clear that the gap between the have's and the have-not's will widen considerably unless this reshaping is inherently based on equity with respect to information and communication. The term "equity" must not only be defined to mean universal access to information and technology, but it must include the opportunity for all to gain the knowledge and skills necessary to access information when it is needed, to translate that information into useful knowledge, to problem-solve and effectively communicate results using these new tools.

At the heart of this evolution into a new educational system is community, and inherent in the success of this new education n system is the need for that community to be informed and to make intelligent decisions.

Learning Structures

With equity as the basis of this new public education system, current structures must evolve, change and transform to empower the individual as a functioning member of the local and global communities. This translates into an education system which is very client-oriented and which includes agreement on learning goals and the alignment of all teaching, learning approaches and assessment/evaluation measures toward the achievement of those goals.

Schools must evolve to become learning centers for local and global communities. In an era where the only constant is accelerating change, learning centers must be client-oriented, focusing on empowering the learner to gain social, academic and applied knowledge and skills which serve as a strong basis for learning throughout life. The current trend toward national goals and standards recognizes this balance between the need for local autonomy and the fact that students are members of a global economy. This means keeping an "eye on the prize" and encouraging creativity and flexibility in the definition of what "school" means in terms of time, space, staffing, facilities and instruction.

The role of technology and telecommunications in such a system is multi-faceted. A critical component of every learning center must be the empowerment of each learner to effectively use the technology to achieve their learning goals. This means putting the technology in the hands of children and youth, enabling them to gain the knowledge, skills and self-confidence to use these tools in relevant ways, toward products and processes that are meaningful to them. It also means the investment of significant time and resources in ensuring that educators model the use of technology to improve efficiency of the management and administrative side of the system, as well as the creative, learning side.

And it means using the unique features of the technology and telecommunications to bring new dimensions to learning. For example, the armed forces as well as business and industry have developed learning modules which actually train students by engaging them in simulations. If the technology can enable Boeing to design, build and test the 777 using nothing but computer-generated models, it can simulate learning experiences for children and youth. The challenge is the technology transfer of these business and/or military models through research and development into effective, affordable learning modules for K-12 education. Again, this will not be possible without public policy support.

Within a public education structure which ensures equity and achievement of national learning goals and standards, learning centers should be given the autonomy and flexibility to be creative and innovative in bringing the optimum learning opportunities to each student. Technology and telecommunications open doors in this arena, bringing interfaces, productivity tools, information access, creativity tools, open-ended curriculum, and communication tools to the system to meet individual needs, individual learning styles and individual interests. This could translate into "schools within schools," remote access to learning opportunities via telecommunications, creation of "virtual schools" based on interests rather than geography, neighborhood centers, home schooling and combinations thereof.

The role of the teacher and learner changes significantly in such a system. It is critical that the teacher, student and parent collectively understand and agree to a learning plan which meets national and state standards but at the same time empowers the student to make decisions within that framework under the guidance and direction of the educator, the

parent and/or a community advocate. One of the beauties of the technology is the electronic communication that could connect students to advocates, mentors, experts, teachers and peers. To date these resources exist (e.g., expertise of senior citizens, of citizenry, of the business and industry community, of peers) but remains largely untapped. This electronic access could also enable learners to tap into "informal education" facilities such as zoos, museums and science centers which are today largely placebound, expecting audiences to actually travel to the site rather than being able to electronically visit.

This concept will be extremely important as communities bring the concept of internships to the "education to career" models and begin to realize that students are not in the same geographic locations as the businesses with whom they want to intern. One of the potential solutions is virtual workgroups, connecting students and mentor businesses in on-line interactions which enable students to intern without being physically at the site on a daily basis. Currently over 11 million Americans are telecommuting, working on-line from homes and satellite offices, saving their employers overhead costs, themselves transportation costs and time, to say nothing of the positive environmental impacts.

The acquisition of data and information does not have to happen on-site at learning centers, but the processing of that data and information through thoughtful, interactive dialog, discussion, debate and product development can be accomplished very effectively at learning centers, facilitated by educators.

Infrastructure and Information Access

At the core of these community learning centers is an information/communication infrastructure that provides universal, equitable access to information and technology for all learners of all ages. This will require national standards and protocols, and strong public policy to ensure partnerships are formed nationally and locally among education, community, business and industry which collectively support the deployment, operation and sustainability of such an infrastructure. With such strong public and private investment must come access and learning resources for all citizens.

Libraries must evolve to provide seamless access to text, voice, video and data on demand in a variety of print, non-print and digital forms. Learners will continue to need experts such as librarians to design and guide "just in time" access. The whole concept of education in the information age is predicated on students' access to primary source data at affordable rates. It is critical that, as this happens, the broadcast, entertainment, education, government and telecommunications entities collaborate to ensure affordable, high quality access to core services, experts and information for all citizens. Public policy must support and incent such collaboration.

Support for Evolution into New Structures

The real evolution in K-12 education will happen when learning centers become community learning centers, drawing in and leveraging business and industry as well as community resources and opening up the K-12 structure to provide learning benefits to all ages.

That evolution is also predicated on:

- public recognition of the need for significant change in the education system toward learning goals which are in sync with an information/communication era;
- significant investment in systemic change which engages communities in designing, implementing, and assessing shifts toward a new model, with time and resources to support educational professionals, communities and learners in the transition;
- redefinition of learning involvement to include museums, libraries, zoos, business and industry, communication centers, etc.;
- the assurance of equitable universal access to information, the knowledge and skills to use technology and access of affordable on-line information;
- regulatory flexibility for school districts which will encourage and incent creativity and innovation in the design of learning environments which are student-centered, information/technology-enriched and community-based;
- the modernization of learning sites to include technology equipment and access to robust telecommunications avenues. The rewrite of the Communications Act of 1934, currently before Congress, should include industry support for "universal service" to subsidize telecommunications access for schools;
- the transition of public and school libraries to seamless systems through which experts and expertly designed search engines assist learners in accessing any where, any place, any time;
- new models for teacher and administrator certification, credentialling and education which acknowledge the importance of knowledge and skills in the use of technology and telecommunications for teaching, learning, administration, and management;
- the rethinking and redesign of assessment/evaluation systems such as standardized tests and college entrance exams to ensure alignment with agreed upon goals and new learning structures;
- the investment of resources and/or incentives for technology transfer and new research and development which supports the design of sound K-12 technology applications;
- a strong connection with business and industry and community groups through partnerships, joint research and development, internships, facilities, shared personnel and shared infrastructure.

These strategies support the belief that significant systemic change can and must happen at the local level, but only through simultaneous federal and state leadership, alliances among all stakeholders, local empowerment, adequate resources, commitment through ongoing staff development, strategic planning and incremental implementation guided through continuous assessment and updating of a dynamic national agenda.

Thank you for the opportunity to share these perspectives and insights with your committees today.

For further information contact Cheryl Lemke, Associate Superintendent for Learning Technologies at 217/782-5596 or clemke@isbe.state.il.us on the Internet.

Chairman GOODLING. Dr. Brown?

STATEMENT OF DR. ALAN S. BROWN, SUPERINTENDENT OF WAUKEGAN PUBLIC SCHOOLS DISTRICT 60, WAUKEGAN, ILLINOIS

Dr. ALAN BROWN. Thank you, Mr. Chairman.

I would like to note that Waukegan District resides in Congressman Porter's District, a good friend and a good friend of education.

On Friday, March the 10th, 1995, Secretary of Education Richard Riley visited Waukegan to view our K-12 Technology Program.

He had the opportunity to visit with both students and teachers who are using technology integrated into their daily curriculum to enhance learning.

At the press conference to assess what he had seen, he stated, and I quote from the Waukegan News Sun:

"What we have seen here today I think represents the future of education."

I am going to repeat that. "What we have seen here today I think represents the future of education."

There are many school districts in this country that are doing many good things regarding technology and learning. In the complete written text which I have submitted for your consideration, I illustrated what I believe would be the classroom of 2015. It is a little vignette and I hope you have had a chance to read it in terms of what two teachers in our district would be doing 20 years from now.

In Waukegan, which is both an Illinois State Board of Education Model Demonstration Site for Technology, and a U.S. Department of Education Challenge Grant District, we believe that integrating technology into the curriculum and the classroom to reform schools can be done and is being done in classrooms across America.

Our classrooms without desks and classrooms without walls program has provided teachers and students in Waukegan the tools to move to a higher plane of learning.

Past innovations from the pencil to the VCR are and have been hailed as the next panacea for education, but these new tools in the hands of teachers continued to keep students in the role of passive learner, and the teacher in the role of primary provider of the learning.

The use of computers and other forms of communication technology can have a significant impact on a classroom environment if used properly.

Now Waukegan is a district of approximately 13,000 students. We are 70 percent minority. We are approximately 50 percent Hispanic. Our school, our community is a wonderful community. It is a working class community.

We are on about the national average in terms of expenditures per pupil.

We are not a rich district. People say, well, you are along the North Shore. Well, we do not share in some of that wealth.

Our expenditure per pupil is about $5400. We have neighbors who spend that $14,000 that Cheryl was alluding to.

It is a school district that is very concerned about its students. That is illustrated by our Challenge Grant.

We leveraged with the money we got from our Challenge Grant an additional $6.1 million from our 16 partners to provide services, technical assistance, and dollars over the next five years to more than—to double the amount of money that we got from the Challenge Grant.

That incentive from the Challenge Grant energized our community, and it has put us in a position where we can take this technology to more and more students in our school system.

I will talk a little bit later about what some of the results have been on our pilots, but—well, this is probably as good a time as any to mention it.

The pilot classrooms we've had, where I've illustrated here, we have seen an increase in our test scores in these kids.

Where they have had the opportunity to use the technology in the manner that has been described by all the panels, we have seen some very positive results initially. NCREL, the North Central Regional Educational Laboratory, will be doing extensive study on Waukegan over the next five years as we spend this money.

But I am confident that we are on the right track in terms of what we are doing in the classroom.

I see three major factors that will bring about this significant paradigm shift, and it is really important that we focus on these things. Now a little later I will have some recommendations as to how I think we can get there.

First is the technology itself. It is interactive and two-way. It is generative and creative and prescriptive for kids.

What does this mean?

It means that the student use is not limited to just learning in the classroom; that the student will be able to use multiple sources of information; that the technology will be assistive in helping the student create multi-media presentations in the classroom; and enabling students and teachers to become active, engaged learners.

Next is the school structure. I know this is something that is hotly debated is what is going to be the school structure and what are we going to do to change?

I really believe that the classroom will be more collaborative than it is now. You know, we talk about home schooling, and we talk about, you know, kids being out on their own learning, but believe me the teacher role will be even greater in this collaborative because the technology will pull them together.

They may not always be physically in the same place, but they will be working together in a collaborative venture to learn together.

Well, I am not going to comment on the first panel because I have cooled off somewhat since then, so I am going to move on.

But it will feature expanded educational resource markets; that there will be a greater emphasis on family learning and greater student mobility for learning. Laptops, for instance, which will be one of our next phases, where our students will receive Laptops to take home, to take to museums, to take on field trips, to actually have their programs with them to where they can actually start putting their presentations together before they get back to the classroom.

In order to accomplish this, I think there will be less grading. I do not mean the kind of grading of A, B, C, D, I mean less grading. I see more age grouping. I think that will happen, so that kids can learn from each other.

Older kids can teach younger kids. I think teachers will appreciate this happening, because they will not be able to get around to everyone.

I think there will be less age grouping in the future. I think that more electronic sources of information available to home and school will connect the two electronically; that you will see more communication between families and homes and school electronically; maybe even a transfer of homework; electronic hotlines; grades being transferred electronically; and so on.

What will be—the third factor is. What will be the role of educators in this?

The pervasive style of teaching will be learning by doing. I am convinced that we will see that happening, as we are in Waukegan now, where process is emphasized more than content.

I want to say that again for effect. Where the process is emphasized more than content.

The first panel did talk about the fact that how we learn and how we can research and how we can continue to use data and manage data in the work place will be more important than some of the things that we would learn in pencil-paper activities.

Assessment will be more performance-based with student portfolios maintained on each student by the teacher, both electronic and paper.

In addition, the curriculum will be somewhat student-driven. If the students want to do a poll to learn math, to learn interactive activities, to be involved in interpersonal communications, they could pick their topic, for instance, as to what they might want to poll people about.

What this means is the teacher also will team with multi-age students to participate in collaborative problem-based learning projects which promote more of a Socratarian model of instruction.

Assessments will be product- oriented, and students will be able, to some degree, to guide their own learning.

Now what I would like to talk about now are how—or I think your next logical question is. Well, how are we going to get to this in public schools with strictly a district like Waukegan, which I think represents more districts than the two-tiered system—two-tiered cast system that some of the people in the first panel advocated where everyone can be home-schooled by loving parents.

I can tell you, I have a homeless coordinator. I have a homeless coordinator that makes sure that the kids that go home to live in cars and shelters have books, have clothes, and have food.

They are not worried about whether they are going to be able to go home and get on the Internet and work with their parents and answer any questions about how was school today. They are worried about where their next meal is coming from.

The first thing I would recommend is that we create a national technical advisory council, NTAC, if you will, to recommend objectives for districts and educators to follow. This council would develop technology guidelines, implement implementation procedures,

and instructional strategies in conjunction with CDAR, the Department of Education, businesses, universities, state boards of education, and local school districts.

NTAC, or this national advisory council, would not determine what schools teach, such as the content, but would provide an effective tool for instruction.

In what Cheryl alluded to, small rural districts, where I had an opportunity to keynote five counties in southern Illinois last week, they are just getting started.

They do not have the resources, the manpower, the technical assistance they need to put this kind of program together that we may have in Waukegan.

So it is important that they be provided with these opportunities and, at the same time, the guidance that they need.

Again I want to say, we are not looking for another mandate. We are just looking for guidance and incentives. That is number two.

The role of the Federal Government would be to stimulate implementation by funding a collaborative effort of Federal, state, and local school districts along with businesses.

I would propose that, of the 44 million students, that the Federal Government at least put $10 behind each student, which would be matched—this would be a match—by the states and local school districts, thereby putting $30 behind each student for technology.

We have 13,000 students, so that would be approximately $500,000 that we would have available from those sources. I want to go back to our Challenge Grant.

Our community will more than match anything you put into this. I guarantee that. Any community that has the opportunity to say, if you give us a dollar, we will match it with a dollar, and we will find a dollar from another source. I do not think there is any question that you can bring a community together to do that, if you provide that kind of incentive.

Third, provide pilot programs. Pilot model demonstration sites such as Waukegan in each state of the Union would act as laboratories and observation sites for school districts designed to implement an effective technology program.

We are all over the place, and industry would certainly like to sell us all kinds of things. I am talking about the communications industry. There are all kinds of remedies out there that they would love to sell us.

You could, in some cases, refer to them as snake oil.

I have had people come to me in my office and say. If you buy this million dollar package, we guarantee you will raise your test scores, but you've got to throw out your entire curriculum and do what we do.

And there are some school districts that will fall for that. It is important that school districts maintain their curricular integrity, but at the same time have the guidance and have the opportunity to see what is working in the world.

This research is really important. Our North Central Lab has been a great assistance to us. We would not be where we are today if it were not for NCRL.

Number four would be to monitor. I do not expect you to do these things for us, get us moving and then just abandon us, or not continue to try to understand where we are going in this country.

I would recommend that you monitor implementation annually through the National Advisory Council and report back to you annually to this committee or to Congress.

NTAC would report progress on both the recommended qualitative and quantitative aspects of the program, and recommend needed course corrections and possible future funding needs.

A national inventory could be conducted that would indicate the current status of technology in the classroom and where it is headed as the years go by.

I am confident that, much like our goal in the 1960s to go to the Moon, if we come together to implement this program in a united effort on behalf of our students, we can and will be successful in reforming education in the United States.

Thank you for giving me this opportunity to speak to you.

[The prepared statement of Dr. Brown follows:]

TESTIMONY BEFORE THE JOINT HEARING
BETWEEN THE
SCIENCE COMMITTEE
AND THE
ECONOMIC AND EDUCATIONAL OPPORTUNITIES
COMMITTEE

OCTOBER 12, 1995

DR. ALAN S. BROWN
SUPERINTENDENT OF SCHOOLS
WAUKEGAN COMMUNITY UNIT DISTRICT NO. 60
WAUKEGAN, ILLINOIS

Oct. 12, 1995

The school year was off to a good start in 2015 in Waukegan. Annette and Mary were particularly excited this morning. As an instructional team for students ranging in age from 10 to 13, they had taught their students over the past several weeks how to use the new Super Power Point multimedia presentation program. The project they assigned was due today. The assignment consisted of the students and their families visiting the Smithsonian Institute via the Internet to research the impact of the Civil War on the development of literature in the areas of science, math and social studies. The students were placed in collaborative teams to work together in each of the disciplines. The purpose of the assignment was to develop a consensus on the impact of the Civil War on our society today. In addition, they shared with the students a new high-speed electronic file-sharing program that would allow each to work together without leaving their homes, as well as some new equipment they received, Mach I modems.

The students were due in class at any time since this was one of their attendance days. Mary and Annette were very interested in seeing how the kids have improved their synthesis and evaluation skills since the beginning of the school year. The products of their assignment so far have been just a few short team projects designed to enhance the students' technology andinformation-gathering management skills. This assignment on the Civil War was their first major project designed to challenge their ability to analyze and evaluate their findings. Interestingly enough, this was a topic the students chose because of a visit from a Civil War re-enactment troop who performed at an assembly for the whole school. Annette did have some concerns about the assignment, however, because a couple of her students still could not afford some of the new technology in their homes, and she was concerned about the compatibility and speed of data transfer. She made a mental note to contact the district's Director of Technology to see if there were any funds still available to provide one of the new Mach I modems for them. These two students still had one of the old 576 baud modems which haven't been in use since 2008.

Mary and Annette had also assigned a class project in conjunction with the director of the school's multimedia development center. The Civil War re-enactors had been taped on the new one inch diskettes, and the students were constructing a virtual reality program where they could actually participate in the re-enactment of the Battle of Gettysburg. By inserting themselves into the various discussions about how the attack was going to take place, they could interact with the battle plans. In this particular staff meeting that the students developed, the students convinced General Lee that Picket's charge would be futile, and instead they should attack the Union flanks and turn them inward, which would result in the ultimate defeat of the Union Army.

While a classroom of this nature does not exist today, there are classrooms that are developing the concepts such as Waukegan, a Challenge Grant district for the Department of Education. Teachers are using technology to allow students to develop higher order thinking skills, become high-engaged learners and use technology to manage data, conduct research and produce original documents. This high-engaged instructional strategy can be the gateway to significant educational reform in America today. Few educational tools have had the impact on the classroom that technology has had and is still having. Since the creation of the pencil, each new wave has been hailed as the new answer for student achievement and performance in America's schools. The failure of some prior innovations such as television and video is that the teacher was still the primary purveyor of information and knowledge to the student. The role of the student was still to act as an information sponge, soaking up information from the teacher. The teacher was the sole source of information and any participation on the part of the student was considered to be something only for gifted students. The technology was used in a low-engaged and low-tech way.

These new technologies hold a promise of transforming not only the student, but the teacher as well, into co-learners, co-developers and partners in the learning process. Teachers, instead of being the "Sage on the Stage", become the "Guide on the Side." They become the facilitator, mentor, and coach to students and the role of the student becomes that of worker rather than of passive learner. As active learners, their involvement in their learning processes

provides for a better understanding and retention of the knowledge they are gaining. Building on the basics that they have learned, they move higher on Blooms Taxonomy into the role of synthesizer and evaluator of information.

Futurists tell us that students will not only have multiple jobs in the 21st Century but at least 3 careers. In order to transcend from one career to another, students will need to be life-long learners, able to enter and re-enter the work force by improving their workplace skills based on their ability to learn new concepts.

If we accept the fact that educational technology will impact how students learn in the classroom and will transform both teacher and student into collaborative learners, then how can we reach this goal as quickly and efficiently as possible? In Chart I, K-12 Education in Year 2015, you will find that the three major factors creating the kind of educational setting illustrated above are changes in technology, school structure, and educators. While the ever-changing world of technology stays far ahead of the classroom, improvements in the school structure and how educators teach will go a long way in catching us up with changes in technology, society and the real world. It is critical that educators reduce the amount of "lag time" between societal changes and classroom impact. If the various roles defined in column 2 are implemented for each factor in column 1, I am convinced that we will see a significant change in the performance of students in American schools.

Chart II illustrates the pathways where I think this ideal learning environment can be achieved. My comments focus almost entirely on the role of the federal government since this is the forum under which I have been asked to comment. I feel the role of the federal government is critical in creating a cooperative and positive atmosphere necessary for everyone involved to help in the development of this program. The following are a series of recommendations:

No. 1: Creation of a national tecnnology advisory council called NTAC. The purpose of this committee would be to bring together representatives from universities, business communities, state Boards of Education, local school districts and experts in the field to create a model implementation program for school districts to follow. This implementation program would develop electronic specifications necessary for all districts to be in sync on their technology initiatives. The committee would also develop implementation procedures to help

school districts apply these specifications to the proper instructional processes. The subject matter, content and emphasis of the curriculum would still be a local school decision. The technical specifications and implementation procedures would merely be used by the local schools as a tool to place technology in the hands of its students and teachers.

No. 2: That the federal government stimulate implementation of NTAC's technology procedures by providing seed money of $10 per student to local school districts. In order for districts to receive this money, the states would have to match at a minimum the $10, and, in addition, the local school district would also have to provide a minimum match of $10. This initially would provide $1,260,000,000 for the implementation of these technologies in the first year. In addition, business, through NTAC, could establish a national technology trust fund to help match at the local level.

No. 3: That the federal government promote the implementation of these strategies by setting up model demonstration sites or pilot sites in each state in the Union. These demonstration sites would be implemented through the U.S. Department of Education and evaluated through CEDAR (Council for Educational Development and Research). These technology sites could be used as laboratories for experimentation as well as observation for districts in the process of implementing their own programs.

No. 4: That the Congress and Department of Education monitor implementation of the NTAC recommendations through annual reports by NTAC, the Department of Education and CEDAR. These reports would be both qualitative and quantitative, giving Congress the opportunity to measure the impact of its dollars on the number of computers, modems, scanners, etc. in the classrooms and schools as well as reports on the progress students are making towards becoming life-long learners.

Please note, however, that this type of assessment is in conflict with the simplistic and over-used pencil and paper quantitative assessment known as either norm-referenced or standardized tests. While these instruments will have a place in assessing student progress, we must move toward a broader, more comprehensive and more wholistic student assessment program.

CHART I
K-12 EDUCATION IN YEAR 2015

FACTOR	ROLE	IMPACT
TECHNOLOGY	Interactive, mobile and 2-way Ubiquitous, decentralized use Common platforms Generative and creative Prescriptive	Student use not limited to classroom Handle multiple information sources Cooperative efforts among tech. developers Assist in creating of multimedia presentations Interactive and communicative--able to guide students to new areas
SCHOOL STRUCTURE	More collaborative and heterogeneous Expanded Ed. resource markets Family learning emphasis Greater student mobility (classrooms without walls)	Less grading and age grouping More electronic sources of information Home use will connect to school Students more actively involved in learning
EDUCATORS	Learning by doing is pervasive Teach process, not content Performance-based/portfolio assessment Student-driven curriculum	Teachers team w/multi-age students Students in collaborative PBL projects (Socratarian) Assessment is product-oriented Curriculum guided by student interest

CHART II
PATHWAYS TO 2015

FACTOR	ROLE	IMPACT
FEDERAL GOVERNMENT	Create a national technology advisory council (NTAC) to recommend objectives for districts to follow	Develop technical guidelines, implementation procedures and instructional strategies in conjunction with CEDAR, Dept. of Ed., business, universities, and state boards and local schools.
•	Stimulate implementation by funding a collaborative effort of federal, state and local school districts.	There are approximately 42 million K-12 public school students in the U.S. Seed money of \$10/student or \$420 million would be matched by the states and local school district.
•	Pilot model demonstration sites (such as Waukegan)	Through Dept. of Ed. and CEDAR implement and maintain model tech. sites in each state
•	Monitor implementation annually through NTAC reports to Congress	Access both qualitative and quantitative and recommend course corrections and future funding needs.

Chairman GOODLING. I would apologize to this panel. I have always indicated to my group this year that we probably should have one panel, because we all get a dozen other commitments that we have.

Second, I had hoped also that some of you folks might have been on that first panel, because——

Dr. ALAN BROWN. Believe me, so do we.

Chairman GOODLING. [continuing] to bring the real world that you are faced with into the hearing. That is why I kept mentioning on several occasions during the first panel. What about the dysfunctional families? I did not get any response.

Nevertheless, I will turn to Mr. Fawell at this time.

Mr. FAWELL. Thank you, Mr. Chairman.

I agree with your comments. They were esteemed members of academia, but they were perhaps a wee bit up there in the ivory tower.

I am very interested in your comments, Dr. Brown, that has indicated that the local communities and the school districts are not just sitting there not doing anything.

One question I would put to you. Supposing we in Congress did nothing? In your opinion, what would be the implementation of the technological revolution let us say in Illinois—and Ms. Lemke you can chime in here, and also Dr. McGriff.

Dr. ALAN BROWN. I think you will see a shotgun effect.

Mr. FAWELL. The local people are not unaware of this. School districts are not unaware of this. If there is anything that should excite people in education, it is the potential of the technological revolution.

Oftentimes I find the people are way ahead of Congress. We are usually there with our finger in the air saying, oh, I think the wind is blowing from this direction now, and that comes from the fact that people are doing things.

Dr. ALAN BROWN. I agree. I think we would get a scattergun effect to the improvements that you are seeing. You will not see that concerted effort.

Now Illinois I think is moving in the right direction much because of Cheryl's efforts. We are so fortunate to have Cheryl in Illinois.

But again, we do not have the unified goals that we need to move us all in the same direction. I think in the three panels there was I think a consensus that we need to move forward in terms of engaged learning, using high-tech equipment, and again using just high-tech equipment to do Math Blaster, which is a rote math game, is the same as giving the kid a worksheet and making him stay in from PE. That is a misuse of the technology.

So we need to move people to that plane. Unless we have, I think, some standards that people can follow to implement this technology—and certainly industry can help there—that is why I think there needs to be a concerted effort to, you know, bring people together in terms of what is the most effective use.

And there is some real good research out there that, if it is used properly, we can raise test scores. I am convinced that we can.

Mr. FAWELL. I happen to believe that there is a role for the Federal Government to play—

Dr. ALAN BROWN. Yes.

Mr. FAWELL. —but let me ask this question, Ms. Lemke. What is the State Board of Education indeed doing to incite and to give incentives in the legislature to the Illinois communities. Of course I am from Illinois, and I think much of the State, and I know people are out there doing things.

I always cringe a bit—I just add this—when I hear the criticisms of public education today as if it is just an abysmal abject failure.

I happen to have raised three children. They went to the public schools. I think they got a fairly adequate education, I believe, a very fine education. I know they are not perfect.

So I do appreciate every once in awhile some stalwart saying, well, just a minute; good solid criticism we need, but just don't drag us around like an old dog all the time; we are not dead, and we are aware.

So what is the State Board of Education doing, and the State Legislature, to bring incentive to the local communities to recognize the potential here?

Ms. LEMKE. Well, we are certainly making a good beginning on that.

The State Legislature has allocated some dollars during the upcoming school year, and we are doing three major things.

One, we are actually establishing a state infrastructure that will allow school districts to connect to Internet at a more affordable rate.

Frankly, one of the things that we are running into in the State of Illinois is we have 18 LATAs. I think we top every state in the Nation in terms of how many LATAs we have, which means it is very expensive to go from one part—to call from one part of the state to the next.

So the state is helping to equalize that access.

Dr. ALAN BROWN. Tell them what a LATA is.

Ms. LEMKE. A LATA is—when MA Bell broke up, they created these boundaries where you cannot call from one LATA to the next LATA without going through a third long distance carrier, and then also going through another carrier at the end. In essence, it is more expensive, and 18 is a lot of LATAs to have.

The second area that we are investing some dollars in is capacity building for our local school districts. Frankly, we do really believe that dollars follow vision, and school districts cannot capitalize on that unless they understand.

So we are creating six hubs across the state. They will be professional development hubs providing professional development in the areas of technology.

We are actually doing a lot of system design and allowing school districts to get unbiased networking consultation through those hubs.

Information exchange. Frankly, I think that if we just exchanged information about what one district is doing to another, instead of all building from the grassroots, we can build off each others' shoulders, and we are trying to do that approach as well.

The third area is we are granting significant dollars to school districts in the area of conductivity, but we are requiring that they participate in learning projects across networks. If they are inter-

ested in the learning piece and interested in participating in that, we will provide the conductivity so they have full band width access to the Internet.

We are also doing some systemic change.

May I also add, I think there is a role—for your previous question, I think there is a role for the Federal Government. One is the research and development.

I think we have not done a significant job in that arena.

Another one is the whole issue of equity across the Nation. It is at the Federal level, for example, where the regulatory issues are being discussed. I think you have a very significant role, for example, with the universal service access.

Another one—and I am not sure that you are aware of the impact that you have had through the Office of Technology Assessment that is no longer there, unfortunately, with the products that they have put out.

When there is a national study that comes out, everybody in the Nation, from a community perspective, uses that research for leverage and moving in particular directions. I think that is something that we should applaud Congress for having done for many years.

We are frankly very sorry that that has gone away.

The last one is, I think we need to understand some of the drivers that are happening for what the school system is today.

Frankly, one of them is college entrance examinations. I mean, they drive what we are doing in our high schools. When you ask an elementary school teacher what they teach, they say I teach children.

When you ask a high school teacher what they teach, oftentimes they say, I teach academics. One of the reasons is that college entrance exam.

So if we can change that approach so that we can do some of the things that Seymour Papert and Alan Kay talked about this morning, it is very difficult to do within that context that we have.

I think you can help us with that, as well.

Dr. MCGRIFF. Mr. Chairman, may I respond to the previous question?

Chairman GOODLING. Certainly.

Dr. MCGRIFF. The Edison Project takes a slightly different approach.

One, we have set as our mission to be able to create an educational design that can function in every school district that currently spends at or near the national average. So we could work in Dr. Brown's school district.

What we provide to any district who spends at or near the national average is a Laptop for every teacher, a computer in the home of every child, four weeks of training before school opens; two hours of training every single day; and we devote 4 percent of our budget to research and development.

What we need from the Federal Government is that equity issue again, because the large number of the school districts could never have Edison Partnership Schools even though their communities may want them, unless they spend at or near the national average.

Mr. FAWELL. You know, I might add that perhaps every member of Congress ought to have a computer in their home, too. I came

to Congress as a practicing attorney, computer illiterate. I am not what I would call advanced, but I did put a modem into my home.

I can sit down in my little office in my home and have contact with everything that is on the computer in the office, and everything that we can do in Washington I can do at my home. I have my FAX machine. I have the photostat machine. I have a direct telephone contact. And when we are not in session or in committee, I can do everything from my home.

So in a sense, I am telecommunicating, and I think that this is something that we in Congress ought to really insist upon. Because it is only when you begin to see the tremendous potential that is out there that you can gain access—if it is nothing more than just your files, to be able to pick up your complete file and be able to work on it at home just as if you were in Washington, is a tremendous asset.

So that at least gives me some comprehension of the potential that is out there as technology does finally—is finally implemented in our public school systems throughout this land of ours.

Thank you very much, Mr. Chairman.

Chairman GOODLING. Mr. Ehlers?

Mr. EHLERS. Thank you, Mr. Chairman. Just a few comments, and not really a question.

I agree with Chairman Goodling that it would have been good if you had been on the first panel, although we would probably still be here with hammer and tongs going at it.

[Laughter.]

Mr. EHLERS. I appreciate your optimism about the current educational system. Ms. Lemke, you commented about you don't need to change the system, you just have to work within it and improve it.

I do have some sympathy with what the first panel was saying, however, based on my personal experience. Let me tell you, first of all, I was home-schooled, not by choice but because I was ill, and it is a constant surprise to people to find that out since I ended up with a Ph.D. in nuclear physics and ended up in Congress, and unbeknownst to me, became a hero to the home school movement even though I would have rather have gone to school.

It also of course left me a total social nerd——

[Laughter.]

Mr. EHLERS. [continuing] which my colleagues can fully appreciate. But in any event, as I said, I taught for 22 years at the college level, but I specialized, or tried to educate students about how to teach science. So I ended up in a lot of elementary and secondary classrooms.

I really do not share all of your optimism about the present system and what we can do with it. I wish I had some better answers. I am not sure the first panel's answers were that much better than yours, and maybe worse.

But I was struck so often by going into schools at the tremendous variation from school to school, even from classroom to classroom, and I will never forget going into one school where there were two classrooms, same grade level, two different teachers, same curriculum, and in one the students were alert, active, learning, and in the other one they were dead, stultified, and not learning.

I am not saying that all the problems are due to teachers. There are many social factors as well. But I really do think we have to have some new and innovative thinking about how the schools can operate, and particularly how the technology can help in the renovation and rejuvenation of the ideas that we are trying to get across in education.

I think some of the reactions we hear from the educational community—and I do not accuse you of this because obviously you are at the forefront of these things or you would not be here today—but a lot of it is stultified thinking, or even defensive, saying, oh, the system is really not that bad, and we are doing a good job.

That is not going to cut it in the next 20 years. We are facing some very major challenges within the Nation and from without the Nation.

I just wanted to ramble on a bit and express my reservations to your comments, but also to say how much I appreciate your coming here and sharing your ideas. It was certainly a good counterbalance to what we had on the first panel.

So, thank you very much.

Dr. McGRIFF. Mr. Chairman, I would just like to say that Edison does not believe that we do not need to make substantial change in the existing system

Mr. EHLERS. I understand.

Dr. McGRIFF. We simply believe that we have to—we can partner with existing school districts. We can do it within the context of public education.

But our design calls for changes in ten major areas of how schools operate, and technology is only one of the ten. What we have done is to look at the very best schools, whether they are public or private, around the world and selected ten elements that good schools implement.

They have been found to have a profound impact even on those youngsters who come from fractured homes. Because until public schools are able to separate this connection between having a wonderful family and middle-class status with being educated, we will never be prepared for the 21st Century.

Ms. LEMKE. May I concur? I do not mean to imply that we do not need to improve the system, but I believe that we can do it from within the system with your help, and I believe in communities.

I think if we can open up the school so that it becomes a community learning center, and we can take away the isolation of the classroom, we have a synergy that will really improve the system.

Dr. ALAN BROWN. And there is a pragmatic reason for you to provide these incentives. There is not a union contract that is in effect today that would not require us to negotiate the changes that the two gentlemen here insisted have to happen.

It is working conditions. It is a situation that we deal with. We have a wonderful union in our district, and they are very progressive. But at the same time, if I went back to them and said the things that were said by these two gentlemen from MIT, we would have a great deal of discussion about whether we could implement what they had talked about. It would also cost me a great deal of money.

Mr. EHLERS. Mr. Chairman, if I may just respond to that, that is one of the most discouraging things I have found in my experience in the elementary schools, dealing with union rules and some of the requirements there, and particularly when I was teaching an in-service and at four o'clock even though I had three minutes to go to finish the demonstration experiment, a good number would get up and walk out because the contract only required them to stay until four o'clock for in-service.

That is very discouraging.

Dr. ALAN BROWN. I want to say that our union has done an excellent job in working with us. They have been very good about that. But I can tell you that there are some school districts where it would be very difficult to implement these kinds of changes we have been talking about, particularly in the first panel, without extensive negotiations.

Dr. MCGRIFF. I have to have on the record that the Edison Project Partners, with two innovative unions, one in Wichita, Kansas, and a union in Mt. Clemons, Michigan, in both cases agreed to every single change that needed to be made from the longer school day to the longer school year, and a career ladder.

We will not enter a community unless the union is open and receptive to all of the innovations and the design.

Chairman GOODLING. Of course there is no substitute for a good teacher. The one-room experience I had in the first four grades in the little school, and Ms. Yost was outstanding and so was the education. I cannot say the same for grades 5 through 8 in the big school.

Again, it all had to do with the teacher in the classroom.

The second thing it has to do with is the teacher being allowed to be creative and innovative. It depends on the leadership in the school and the leadership at the top.

I am glad you just touched on the last thing that you did touch on, because I have been telling my governor that he can talk about reform all he wants in my great State, but until they deal with Act 195 he is probably not going to accomplish all these wonderful things he is talking about.

I also was going to point out—I was saying all these things for Mr. Ehlers' benefit, but he is not here. I also was going to point out that usually it is the people in the District who hold back change.

In every place I go, the neighboring school district is just a "terrible school district." Their school district is outstanding!

It does not matter where you go. Their school district is outstanding. It is the neighborhood—the neighboring school district that is just pathetic. Oftentimes, you know, you cannot change very much if you do not have them moving.

A couple of questions:

Dr. McGriff, you said two hours of prep every day made me——

Dr. MCGRIFF. How do we do that?

Chairman GOODLING. [continuing] perk up and want to know how many hours in the classroom.

Dr. MCGRIFF. Our primary youngsters have a seven-hour school day, and our elementary through grade 12 youngsters have a 12-hour day.

Teachers are able to get the 2 hours of planning time, or I should say two periods, because in some districts a period is 50 minutes and in another district it is 45—because we provide music, foreign language, art, and physical education taught by a specialist to all children starting in kindergarten.

That is where the kids are when their classroom teachers are engaged in planning.

Chairman GOODLING. So that classroom teacher—two hours, plus what might that classroom teacher have in the actual classroom?

Dr. MCGRIFF. The rest of the day is spent with the youngsters teaching various academic subject areas, because they work an eight-hour or a seven-hour day.

Chairman GOODLING. Okay, that's—so the 12 hours that you talk about, they are not responsible to be there 12 hours, or anything of that nature?

Dr. MCGRIFF. No. We also provide, because we know that some youngsters—there are several other features for at-risk kids that we provide in our program.

We know that some parents are working two jobs, and kids need a before- and after-school care. So we have a before- and after-school program in addition to the seven-hour day and eight-hour day.

The research is very clear that high-risk youngsters forget a lot over the summer because their parents can't engage them in learning activities. So we have a 206-day school year for the children.

All of these things help to compensate for the fact that they have difficult home environments.

Chairman GOODLING. Well, I always mention the $40 billion for Chapter 1 was supposed to have been over and above what every other child got. It was supposed to be before school, after school, saturdayS, summers, and unfortunately in many instances that is not what happened.

The second point you made, something about the average per-pupil expenditure in the country, I was thinking. You know, I have partial responsibility to honor the Speaker by doing something to make sure that D.C. Schools are the model for the country.

Their pupil expenditure at the present time, I believe, is one of the highest in the country.

Dr. MCGRIFF. That is correct.

Chairman GOODLING. So they are way above that average that you talked about.

Dr. MCGRIFF. When we developed our model, the average for the country was $5,500. We can still work with districts who spend slightly below $5,500. And there are a number of districts that spend substantially more than the $5,500 that our model will support.

So basically our model is a way of saying, how do you be more efficient with the money that is currently being spent in the average school district and at the same time be able to provide world class education for all kids?

Chairman GOODLING. I am usually a very good first-meeting—how do I want to say that?—I usually know the individual when I meet them on the first occasion, and I was just wondering where Ms. Lemke was when my new governor was searching all over the

country for a superintendent of the construction. You must have been hiding somewhere.

Ms. LEMKE. I have been in Washington State for the last 10 years.

Chairman GOODLING. A long way away. We couldn't see you for the apple trees.

I appreciated, Dr. Brown, your comment to honor the pioneers. I think you were the one—one of you talked about honoring the pioneers—because again I have been trying to get people in my State to please go out across the state and see the wonderful things that are happening.

But, rather than do that, they just constantly badmouth public education and will not go out and see all the wonderful things.

I just spent Friday down in center city Philadelphia. I saw some wonderful things happening in center city Philadelphia. I wish I could get some of the leadership in the state to do the same. I think they would really be surprised.

I got the message that Challenge Grant and Office of Research and Technology are very important to those of you who are out in the public sector.

You got that message, Mr. Fawell?

Mr. FAWELL. Yes.

Chairman GOODLING. Very good.

Again, I apologize. As I said earlier today, my fear was that by the time we got to panel two and panel three, everybody would be tied up. The Chairman of this Committee in this room, they have a TV set here and I am looking down and seeing him most of the time because he has legislation on the Floor, as well as several other members of both committees are down there offering amendments.

You do not have that privilege to see that TV set—I don't, either, in my conference room.

[Laughter.]

Again, we thank you very, very much.

Are there any other questions or comments?

[No response.]

Chairman GOODLING. Staff, is there anything you want to know that they have not said?

[No response.]

Chairman GOODLING. Very well. We thank you very much. The next time we will have you back and we will have you on with the first panel interspersed between each one of them.

[Whereupon, at 2:29 p.m., Thursday, October 12, 1995, the hearing was adjourned.]

[The following material was received for the record:]

STATEMENT OF ALBERT SHANKER

PRESIDENT, AMERICAN FEDERATION OF TEACHERS

TO THE

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE

AND

COMMITTEE ON ECONOMIC AND EDUCATIONAL OPPORTUNITIES

OCTOBER 12, 1995

Messrs. Chairmen and Members of the Committees:

As president of the American Federation of Teachers, AFL-CIO, which represents 800,000 employees working at all levels of the K-12 education system, I appreciate the opportunity to submit a statement in connection with the hearing on "Educational Technology in the 21st Century."

I go to a lot of conferences on the subject of getting computer technology into the schools. One question I always ask at these events is, "Do you think the business community has conferences about getting computer technology into business?" The answer of course is "no," but why is that? It is because companies all know what business they are in; they know what they are trying to build and sell. If there is some way they can do this better and more cheaply, they make it a part of their process. If that happens to be computer technology, they invest in computer technology and make sure their employees all know how to use it. Businesses know that computer technology is a tool, something they can use to achieve their ends. They do not--if they are wise--allow technology to drive their business.

This is applicable to the discussion of technology and education. People in education have not decided on what business we are in, on our educational product. We have not agreed on what students are supposed to know and be able to do when they graduate from high school. Should they be reading and doing math at a tenth-

grade level? A twelfth-grade level? Or is an eighth-grade level as much as we can expect? What do they need to know about history? Science? Do they all need to know exactly the same things? There is national confusion and disagreement about these questions. You don't find this in other industrialized nations. There is a consensus on what a "product" of their schools should know and be able to do--that is one reason why their students achieve at higher levels than ours.

Unless we also agree, technology won't help us solve our educational problems; in fact, it could make them worse. As businesses know, computer technology is nothing more (or less) than a way of gathering, manipulating, and communicating data. It does not have any focus in and of itself. Unless we recognize that, technology will just be a toy that kids can use to hunt around for the most interesting pictures and exciting games. It will be a way of doing more of what they are already doing at home.

If we do decide what "business" schools are in, there are many things that the communication and data gathering aspects of computer technology can do for us. For example, they offer an alternative to having 2.8 million teachers trying to decide on the best way to explain a concept in math or science or a historical event. With computer technology, we could have some of the best teachers figure out two or three of the best ways of teaching a lesson on the Gettysburg Address, for example. They could offer a lesson plan that they had perfected or questions or examples that they know will work in presenting this topic. These suggestions could be put on a database available to teachers all over the country. Then, when teachers

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in Albuquerque or the South Bronx were preparing to teach the lesson, they could download the suggestions and adopt or adapt them for their own class. In many cases, that would give them a better way of presenting a difficult or complicated idea and better resources than if they sat down on a Friday night or Saturday morning and tried to plan this lesson, along with the 25 or 30 others they had to teach the following week.

Some people say this use of computer technology would constitute a move to make teaching "teacher-proof," which they consider an infringement on teacher professionalism. But you could also look on these lessons as something like the standard techniques that doctors use. Doctors don't try to figure out a new technique or procedure for every patient who comes to their office; they begin by using standard techniques and procedures that are based on the experience of many doctors over the years. Nobody considers this a way of doctor-proofing medicine, although they do have a name for the *failure* to use standard practices--it's "malpractice." The standard practices that all doctors (and other professionals) use contain the wisdom of the profession. The same could come to be true of a national database of lessons that have been polished and perfected by the most skillful members of the teaching profession.

But computers can do more than make ideas and materials readily available on a scale that was, until now, impossible. They can also offer help in presenting concepts that are difficult to put across using the traditional tools of words or a blackboard or even a demonstration. For instance, I've seen a computer program

illustrating a math concept that is easy to say but (if you think about it) very hard to accept. That is, the sum of the angles of a triangle is always 180 degrees. The program allows you to create triangles by moving your mouse and lengthening or shortening the sides of an existing triangle or moving the apex. When you create a new triangle, a measurement of the three new angles comes up immediately, and it is always 180 degrees. As you fool around with that program, you see that you are not talking about one or two or ten triangles--it's an infinity of triangles--but no matter how you change them, 180 keeps flashing up as the sum of the angles. This is something a teacher can *tell* you, but no teacher, however gifted, could demonstrate the awesome validity of this statement about triangles the way this simple program can.

In his book *Schools for Thought: A Science of Learning in the Classroom* (MIT Press, 1993), John Bruer, president of the James S. McDonnell Foundation, which supports research in the biomedical and behavioral sciences, gives a striking example of how computers can help elementary school students master basic physics concepts that often elude even high school students. It seems that most students come to physics (and other sciences) with certain wrong ideas, basic misconceptions, about how the physical world works. A teacher can teach these students the laws of physics, but unless the students really see that their misconceptions, in fact, do not work, the real principles are meaningless to them. Students may be able to recite the principles, but the principles are, essentially, a dead letter. To get around this problem, researchers had computer programmers

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devise a series of microworlds, simulations of phenomena found in the natural world. The simulations allow students to run experiments and test the validity of their naive ideas about physical laws against the currently accepted laws of physics. When sixth-grade students who had worked for two months in a physics program that used the computer simulations took the same test as high school students who had studied physics in a traditional curriculum, the sixth graders outperformed the high school kids. Researchers also found that people who had taught in this program became better teachers because they had a better understanding of the barriers in the way of student learning.

Another way in which technology could be enormously useful has to do with accommodating the varying ways children learn. We all know that, even if schools are very well organized, it is hard to accommodate the different ways and rates at which children learn. Even when teachers talk to a homogeneous group of students, there will be substantial differences in the rate at which students get the material--and many classes are far from homogeneous. Some students will understand the material right away; some knew it before the teacher started to talk; and some are so far behind that the lesson makes no sense at all. That's one problem. Another is that different students learn in different ways. Some understand things better if they see them; others if they hear them; others if they manipulate them. Some children learn best if they do it more than one way. The national database of proven and tested lessons and questions and ideas that I mentioned earlier would enable teachers, in a sense, to prescribe for students, to set them on the path that is most

amenable to their particular way of learning. Or it would enable teachers, if one thing didn't work, to try another.

But even if everybody learned in the same way, the instant communication that computers allow would enable us to do things that we have not been able to do before. I recently learned about a program called "Journey North." It runs from Groundhog Day until the end of school, and the point is to enlist students in tracking the spring migrations of birds, insects, and other animals. Classes--and these are largely youngsters in grades four through six--enter information about sightings of migratory animals in their area and see it become part of a big database that follows the movement of spring migrations. They also track, along with scientists, the paths of some animals that have transmitters attached to them. And they have a chance to ask questions of the scientists who are heading these studies of migration. Though science is intensely practical, students often experience it as being theoretical. "Journey North" and similar programs give students a chance to see how scientific knowledge is built and see their data as a contribution to it.

The computer gives an immediacy to this kind of experience that is very important. There is a good deal of motivation and excitement in the real-time aspect of following the migration of an eagle day by day and in getting instantaneous answers to your questions. It is not like writing to a pen pal in London or Paris and waiting three weeks for the letter to be delivered and three weeks for the answer to come back

This by no means exhausts the contributions that computer technology could make to education. Computers have a considerable potential in creating new kinds of assessments, to name just one more possibility, and some interesting things are being done in medical school examinations. But we have to remember that technology, in and of itself, is not educational. A hammer can be used for many different purposes--hitting somebody over the head, breaking a window, hammering in a nail. Putting a youngster in front of a computer does not create an educational situation. The educational purposes have to be there.

There is one other danger. Information is not the same thing as knowledge--and there is a danger that, in our enthusiasm for computer technology, we will lose sight of this fact. It would be a shame to let technology determine education instead of deciding what an educated person should know and using technology to achieve that. To do otherwise is the equivalent of a company that makes hats deciding that they won't make hats any more because computers don't do it very well; they will become an accounting firm instead. It is to let the technology determine what your purposes are instead of the other way around.

David Gelerntner, a professor of computer science at Yale, described the potential and dangers of computers in education in "Unplugged" (*The New Republic*, September 19 and 25, 1994). His comments are summarized in the following quotation, but I commend the entire article to your attention:

> *Computers should be in the schools. They have the potential to accomplish great things. With the right software, they could help make science tangible or teach neglected topics like art and music. They could help students*

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form a concrete idea of society by displaying on-screen a version of the city in which they live--a picture that tracks real life moment by moment.

In practice, however, computers make our worst educational nightmares come true. While we bemoan the decline of literacy, computers discount words in favor of pictures and pictures in favor of video. While we fret about the decreasing cogency of public debate, computers dismiss linear argument and promote fast, shallow romps across the information landscape. While we worry about basic skills, we allow into the classroom software that will do a student's arithmetic or correct his spelling....

Educators should learn what parents and most teachers already know: you cannot teach a child anything unless you look him in the face. We should not forget what computers are. Like books--better in some ways, worse in others--they are devices that help children mobilize their own resources and learn for themselves. The computer's potential to do good is modestly greater than a book's in some areas. Its potential to do harm is vastly greater, across the board.

Thank you for inviting me to express my views. I regret that I could not appear before you in person and would be happy to follow up on any questions my statement may generate and to provide you with additional evidence for my views.

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Presentation by:

Shelly Weinstein, President & CEO

National Education Telecommunications Organization

and

EDSAT Institute

Testimony

U.S. House of Representatives

Joint Hearing

on

The Future of Education Technology

House Science Committee

and

House Economic & Educational Opportunities Committee

October 12, 1995

Rayburn House Office Building

Washington, D.C. 20515

National Education Telecommunications Organization/Education Satellite
1735 I Street, N.W. Suite 601 Washington, DC 20006 202-293-4211 voice 202-293-4210 fax 800-220-1235 toll free

Good Morning,

My name is Shelly Weinstein and I am the President of the National Education Telecommunications Organization (NETO) and the EDSAT Institute (EDSAT). NETO/EDSAT is a non-profit, voluntary "education users organization" established to govern and manage affordable and equitable satellite and other telecommunications services on behalf of America's education institutions, governments and other distant learning centers.

Our members, located in more than 35 states, include school districts, colleges, state agencies, libraries, public/private education consortia, private sector representatives and individuals. The goal is to create an integrated, nationwide telecommunications system--a "transparent seamless highway"--that encompasses land and space, over which teaching, training and other educational resources can be delivered to schools, colleges, universities, libraries, government agencies, and the workplace.

NETO/EDSAT's mission is to help open access to and the use of end-user information tools in formal school settings and classrooms nationwide (and ultimately, internationally) such as telephones, computers, faxes, video cameras, and/or television sets.

An objective is to give every school unlimited access to a interconnected multi-technology transportation system that carries teaching, instruction and information in all forms--video, voice and date--from almost anywhere in the nation or world.

Technology has rapidly transformed every sector of our society except education. Although telecommunications has turned the world into a "global village", America's schools for the most part have remained relatively isolated enterprises. While the educational resources available in this nation and around the globe are rich and growing exponentially, the United States is without technologically integrated telecommunications infrastructures to "transport" major products and services of an information economy, i.e., instruction, education, training and information.

A nation's education systems are endemic to economic development and productivity. We also know that growth and productivity are closely tied to the level of telecommunications "use" in industrial and developing nations. In testimony befc e the Subcommittee on Technology and Competitiveness, House Committee on Science, Space and Technology (June 18, 1991), the U.S. Chamber of Commerce pointed out that the U.S. invests:

> "only about $100 per student in education in ... capital investment compared to $50,000 per worker in private industry and $100,000 per worker in high tech firms."

If one applied an international measure to America's telecommunications frastructure dedicated to education, the U.S. education sector's use of telecommunications roughly compares to that of a developing nation.

The EDSAT Institute's report in 1991, "Analysis of a Proposal for an Education Satellite", found that individual states and educational institutions are investing heavily in telecommunications technology. The technologies through which instruction is delivered at the local level includes copper wire and fiber, co-axial cable, microwave and fixed-based broadcast television as well as receivers for satellite transmission. All land-based technologies are essential to an interconnected

electronic infrastructure and satellites are the most cost-effective means by which to distribute multiple education programs, simultaneously to every part of a state and the nation, at relatively low unit cost.

The market to support an education satellite and other telecommunications already exists. There are more than 200 small education program providers using satellite-based telecommunications to deliver instructional programming into classrooms and workplaces. Educators spend approximately $500 million annually on distance education with approximately 1/3 of the costs for satellite time.

More than 90 U.S. colleges and universities deliver degree, non-degree, graduate and undergraduate courses through satellite, telephone and cable transmissions. They use more than 100,000 hours of satellite time and reach millions of students, teachers and workers domestically and internationally.

In its totality the education sector has the potential to be the biggest user of telecommunications comparable to, if not greater than, the commercial sector. Despite this high level of use the U.S. has not created an affordable, accessible and equitable transmission highway governed by market demand and need, dedicated to transport instruction, information, education, and teaching--an I-95 of education.

The U.S. economy has always benefited through its worldclass transportation infrastructures. U.S. transportation systems have been effective and economical when they provide access to increasingly greater numbers of users; when the primary system interconnects through multiple secondary and access systems with user friendly maps, tools and standards. Armed with this knowledge the U.S. economy still asks small and large education providers to use commercial highways designed for broadcast, voice and data, with exclusivity, limited and preemptible access and preferential pricing based on quantity, distance and bandwidth.

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These models are more often than not incompatible with the education market demands and needs. The broadcast and voice transmission models are less than conducive, if not barriers to establish a space-based transportation system to deliver cost-effective products and services adequate for teaching and learning tools.

The satellite business has grown exponentially over the years because it has responded to the needs and demands of targeted large markets. The satellite industry has compatible financial structures and business policies to meet their user demands and needs. As a result, this nation has 'cable' satellites, 'voice' satellites, 'military' satellites, 'direct broadcast' satellites, 'weather' satellites, and apparently 'National Recognizance Organization' (CIA) satellites.

Why shouldn't the world's leading democracy in a global economy, i.e. the U.S., have an education satellite? Why shouldn't the huge education industry receive the same economic benefits as other industries when they need their own satellites? After all, the education sector pays its own way. Collectively schools, colleges and states are big buyers. This can be seen by the growth in the use of telecommunications in education. It has been nothing short of phenomenal, costly and chaotic over the last ten years. Access and use of telecommunications in teaching and learning is fragmented, disorganized and for the most part underutilized in classrooms.

- Taxpayers, governors, students and teachers are not getting much bang for their buck with disorganized and fragmented spending.

- Educators spend $500 million annually on distance education. It is expected to exceed $2 billion by the late 1990's.

- Over 90 US colleges offer degree, non-degree, graduate & undergraduate courses through distance education with access to approximately half a million students.

- The percentage of school districts out of 15,000 using one or more satellite dishes ranged between 33% to 50% in the 1992-93 school year. This growth took place largely in rural and urban areas.

- In 1984 US schools had one computer per 200 pupils. In 1994 there was one computer for every 15 - 20 pupils. Few school budgets take into account the regular operating and long-distance costs for telephone lines.

- There are more than 11 federal agencie delivering education and training through Video Teletraining (VTT) Networks.

- Roughly 200 education program providers deliver education, instruction and training through access to classrooms and workplaces. Program providers are colleges, school districts, state agencies and others.

- The U.S. has 57 Education and Training Networks in healthcare, government services, education and military training.

- The US Department of Defense spent more than $25 million to install 450 receive sites for six DOD/Services Education Networks, not including operating and audio (long distance) costs.

However, many of the 200 education providers offering curriculum and interactive instruction in this field, known as distance education, are at risk. Distance education began to offer a bright light at the end of the tunnel about ten years ago for millions of students and teachers by giving them access to math, science, languages, technologies, research and teacher training which would otherwise not be available due to geography, wealth and population density. The distance education promise has been temporarily dimmed due to shortages and unstable price increases in the satellite industry. (APPENDIX "A")

NETO/EDSAT points out that there are few, if any alternatives to satellite services for institutions with limited education budgets. Fiber lines are no answer because it landlocks students' access to teachers and educational resources and it is too costly to operate for multiple classroom use for the foreseeable future. (APPENDIX "B") Cable or copper lines offer the local link or connection into the classrooms, the last mile. Satellite offers a cost-effective instant interactive nationwide highway. As some would say, "launch a satellite and our school children have an instant highway to educational riches".

U.S. schools are frequently described as "low-tech" in a "high-tech" society. This belies the interrelationship between the U.S. education systems, its economy and well being of society. U.S. schools are, at best, in a high-tech society with infrastructure which is largely comparable to those of a developing nation's.

There are strong indications that many developing regions such as the Pacific Rim, the Caribbean and Eastern European Countries that are striving to balance economic development, democracy and political stability, may likely outpace the technological capabilities of US schools within the next 8 to 10 years. Where is that likely to leave future U.S. leadership and economy?

What technical aspects are needed to sustain the large and small education programmers and encourage new growth along with cultural and ethnic program diversity? Education users need state of the art, multi-technologies which interconnect nationwide and are interoperable over satellite, cable and telephone lines directly into classrooms, workplaces and distant education centers

There are far too many school districts out of 15,000 that cannot demonstrate an exemplary information project. Is it Congress' role to develop more "projects", regional or local? The time has come for Congress and states to develop a nationwide vision, strategy and tactics with plans, maps and standards to encourage access to our vast educational resources and teaching expertise to preserve local identity and control and blind to geographic location or wealth of the community. Parents and students expect their educational institutions to provide an equitable educational opportunity suitable to meet the rigors and demands of a global information age economy, its workplaces, its workers, their family and community responsibilities.

The education sector has unique and discreet practices; it has a public interest mission; and it is endemic to national economic security. The education users; our communities, parents, students, and the private sector must control their own destiny through inclusive policies, equity in pricing and open access to encourage more, not less choices.

There is a key role for industry and technology. Governors and educators have a role and the federal government has a role. Together the three sectors form a force far larger than the sum of their parts.

NETO/EDSAT congratulates Senator Conrad Burns (Montana), Congresswoman Constance Morella (Maryland) and Congressman George Brown, Jr. (California) on their efforts to dedicate NASA's unused satellite capacity for schools throughout the nation, as a response to the immediate crisis facing education users who are likely to lose business, become destabilized and underutilized by September of 1996 because of satellite shortages and high pricing

Historically NASA has made use of its satellites outside its programs to encourage and help small commercial firms use space for greater economic benefits. A timely dedication of NASA's unused C-Band satellite capacity for prime-use by the education sector will help NASA reach its goals and greatly benefit students and teachers, nationwide.

Additionally, NETO/EDSAT supports Congresswoman Morella's and Ranking Minority Member George Brown, Jr.'s education satellite loan guarantee program (HR1908) to minimize the risks for private sector investors and establish an adequate satellite system dedicated to education.

The U.S. is well into an information era absent a transportation system for educational institutions to deliver and use the major products, services and human resources of an information economy, i.e., education, instruction, training and information!

Imagine if you will, former President Dwight Eisenhower telling this nation he would build a highway, coast-to-coast, to give American families access to job opportunities, education, housing and other social benefits which far exceeded their greatest dreams and expectations. Then tell the governors to build their state and local area highway systems while hoping that industries' promises and engineers will somehow make it all connect! You and I know it didn't happen that way for this nation's Interstate highway systems whether by rail or auto and it won't happen that way for an Interstate education electronic highway system.

Industry leaders who support NETO/EDSAT's mission and efforts to establish an education satellite include AT&T SKYNet Satellite Systems, Discovery Communications, Westinghouse, Orion Network Systems, American Community Services Network (ACSN /Psaras, Inc. Fund), Southern New England Telephone Company and others. Additional support is received from school districts, state agencies, public and private colleges and state agencies, public and private colleges and university systems in more than 35 states along with nationwide and regional education organizations. Many federal agencies work with and seek NETO/EDSAT's services.

Materials/Appendices with Testimony

Appendix "A"............... NETO/EDSAT Media Advisory Package

Sept/Oct 1995 Advisory

March 1995 Advisory

Appendix "B".............. Article: Sept 1995 Communications Industries Report: *"North Carolina Superhighway in Slow Gear"*

Appendix "C".............. NETO/EDSAT Background Package

Overview

Policies & Purposes

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21-035 - 96 - 10

MEDIA ADVISORY - SEPT/OCT 1995
FOR IMMEDIATE RELEASE

NETO/EDSAT congratulates Senator Conrad Burns (Montana), Congresswoman Constance Morella (Maryland) and Congressman George Brown, Jr. (California) on their efforts to dedicate NASA's unused satellite capacity for schools throughout the nation, as a response to an immediate crisis facing school programmers who are likely to go dark by September of 1996 because of unexpected shortages in satellite capacity and the accompanying skyrocketing price increases.

Burns, Morella and Brown have gained national recognition for their leadership in helping to open access and the use of telecommunications in U.S. classrooms in recent years. The long-term focus is on loan guarantees to encourage a public/private partnership to establish an adequate satellite system interconnected with other telecommunications dedicated to students, teachers and workers for instruction, training and education. And, for a limited period make NASA's unused infilte C-Band satellite transponders available to schools, colleges, states, libraries and other education centers as the prime users.

David Taylor, NETO Chairman and Dean, Western Illinois University, College of Education and Human Resources states, "NETO/EDSAT is pleased at the positive reactions and cooperation NETO/EDSAT has received from satellite industry leaders. Many persons in the satellite industry have education customers and know they are unable to meet their needs due to the shortages and price increases. Industry leaders view NASA's dedication of the unused capacity as a positive temporary step to keep small education users in business and ultimately to create an education satellite with loan guarantees."

The infant U.S. distance education field is at risk. It began to offer a bright light at the end of the tunnel about ten years ago for millions of students and teachers to gain access to math, science, languages, technologies, research and teacher training. Its promise has been temporarily dimmed due to the shortages and price increases in the satellite industry.

The satellite business has grown exponentially over the years because it has responded to the needs and demands of targeted large markets, with financial and business policies which are compatible with how the user does business. "As a result, this nation has 'cable' satellites, 'voice' satellites, 'military' satellites, 'direct broadcast' satellites, 'weather' satellites, and apparently 'National Recognizance Organization' (CIA) satellites," states Shelly Weinstein, President & CEO, NETO/EDSAT.

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appendix "a" 1

Weinstein asks, "Why shouldn't the world's leading democracy in a global economy, i.e. the U.S., have an education satellite? Why shouldn't the huge education industry receive the same economic benefits as other industries when they need their own satellites? After all, the education sector pays its own way. Schools, colleges and states spend about $500 million annually, on distance education about a third of which is spent to buy satellite time. Collectively, they're a big buyer by any stretch of the imagination. NETO/EDSAT regrets NASA's delay in dedicating this capacity to education."

NETO/EDSAT points out that there are few if any alternatives to satellite for institutions with limited education budgets. Fiber lines are no answer because it landlocks students' access to teachers and educational resources and it is too costly to operate for multiple classroom use for the foreseeable future. Cable or copper lines offer the local link or connection into the classrooms. Satellite offers a cost-effective instant interactive nationwide highway. NASA will not incur any costs upon the dedication of this capacity to education as the prime user. It will be of great benefit to U.S. taxpayers and their schools to make use of this unused power currently going to waste.

Historically NASA has made use of its satellites outside their programs to encourage and help small commercial firms make use of space for greater economic benefits. A timely NASA decision to dedicate the unused C-Band satellite capacity for prime-use by small education organizations will help NASA reach its goals and greatly benefit students and teachers, nationwide.

The National Education Telecommunications Organization (NETO/EDSAT) is an independent Washington based, not-for-profit organization established to improve and reform American education through the use of an integrated nationwide satellite-based telecommunications system linked with cable and telephone lines dedicated to education, instruction and training. NETO/EDSAT members include school districts, state agencies, colleges and private sector programmers who use telecommunications technologies to receive and send education, instruction and training. NETO/EDSAT is supported through government contracts, corporate and individual contributions.

For further information on NETO/EDSAT contact Shelly Weinstein at 1-800-220-1235 or FAX 202-293-4210. You may also want to contact your Congressional representatives through their e-mail address. This press release can be found on the Internet at (http://www.fortecom.com/neto.html).

MEDIA ADVISORY

MARCH 1995

NETO/EDSAT WARNS OF CRISIS IN UNITED STATES DISTANCE EDUCATION

FOR IMMEDIATE RELEASE:

The National Education Telecommunications Organization and EDSAT (NETO/EDSAT) warn of a fast oncoming telecommunications crisis which will put small education entrepreneurs out of business! Hundreds of colleges, school districts and state agencies deliver teaching and education resources to tens of thousands of classrooms and workplaces.

"An unexpected, critical shortage and increased costs of satellite transponder capacity will force many, many small independent education providers to go dark and out of business," said Shelly Weinstein, President & CEO of NETO/EDSAT.

Hundreds of colleges, school districts and private corporations deliver live interactive courses with instruction, using more than a hundred thousand hours of satellite time. It's enough hours to fill up almost 40% to 50% of a large geosynchronous satellite but occasional education buyers are spread out over half the in-flite domestic satellites.

Dr. Smith Holt, Dean, College of Arts & Sciences, Oklahoma State University and NETO/EDSAT Board member, points out that "unfortunately a massive erosion of the availability of transponder space and a major escalation in its costs are occurring. This unanticipated shortage was caused by launch failures, underestimating demand and overestimating market shifts in technology. The effect is that some education providers have already cut-back course offerings for the 1995 Fall Semester, while others are predicting loss of viability within eighteen months should remedies not be enacted".

more

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MEDIA ADVISORY -continued

Page 2

Educators spend almost $500 million annually just on Distance Education, the delivery of courseware and teaching, at all education levels (K-12, degree, non-degree programs, etc.). Spending is projected to reach more than $2 billion within the last half of the 90's. States and school districts spend public tax dollars on satellite, cable, telephone, ITFS, microwave and satellite dishes to deliver educational resources, cost-effectively. "They cannot be limited by or change to a single transmission system without incurring massive additional costs", says Weinstein.

NETO/EDSAT believes that educators should have equitable access and utilization of cost-effective interconnected multiple technologies to let teachers and students have user-friendly tools in classroom settings.

For the short-term NETO/EDSAT is seeking access to unused government owned satellites. For the long-term Congress must provide a no-loss loan guarantee program for the private sector to create a satellite interconnected with land-based, telephone and cable systems, dedicated to education. AN ELECTRONIC INTERSTATE HIGHWAY SYSTEM FOR EDUCATION, INSTRUCTION AND TRAINING FOR THE TWENTY FIRST CENTURY!

The National Education Telecommunications Organization (NETO/EDSAT) is a Washington based, not-for-profit organization created to improve and reform American education through the use of an integrated nationwide satellite-based telecommunications system linked with cable and telephone lines dedicated to education, instruction and training. NETO/EDSAT members include school districts, state agencies, colleges and private sector programmers who use telecommunications technologies to receive and send education, instruction and training. NETO/EDSAT is supported through government contracts, corporate and individual contributions.

- end -

March 1995

THE TRANSPONDER CRISIS

The distance education industry in the United States serves virtually all of the nation's 16,000 school districts, providing access to coursework otherwise unavailable to students (e.g. advanced mathematics and science, foreign languages, remedial reading and enrichment programming), in-service for teachers, training for administrators, as well as a host of other vital services. These services are in jeopardy!

In order to reach the schools in America, the universities, school districts, and private corporations that originate satellite programming consume between 85,000 and 100,000 hours of transponder time. Given the magnitude of the demand, access to satellite time at an affordable cost is crucial if the industry is to perform its vital function. Unfortunately a massive erosion of the availability of transponder space and a major escalation in its costs is occurring. The following are the facts.

The availability of C-Band transmission time has reached a near critical shortage.

- Changes were caused by the failure of Telstar 402 in September 1994.
- As of January 1, 1995 the only C-Band satellites with occasional space are Satcom C1, Galaxy 3, Telstar 302 and Telstar 303.
- Many transponders once used for occasional time have been leased full time by networks or other private companies to ensure their programming has delivery space. It has been publicly announced that one major cable company just leased the remaining 17 transponders on a Hughes satellite to protect its delivery space.)
- Between October 1994 and year-end 1995 there will have been a 16% reduction in C-Band capacity.

In the recent past, transponder time could be purchased up to six months in advance.

- Now, AT&T books only 4 months in advance and Hughes only 3. AT&T has a minimum 25% cancellation fee. (In the past there were no charges unless canceled within thirty days of the broadcast.)
- AT&T no longer books on inquiry or allows flexible end times (approximate ends), all time must be booked firm.

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THE TRANSPONDER CRISIS (continued)

Until the shortage, C-Band time could usually be found with one or two phone calls from the broker.

- Now seven to nine calls to find the space for occasional feed.
- In some cases confirmation comes one or two weeks prior to the broadcast. (One result is that this eliminates the option to exercise the "30 day cancellation")

The other significant change is pricing.

- Individual satellites and transponders now brokered at different rates.
- Three price increases since July 1, 1994 with more expected. (Time that could be had at $130/hr before July 1, 1994 now costs upward of $350/hr).

KU-Band has seen changes due to the shortages.

- C-Band or KU-Band is fungible in the commercial sector, therefore though KU-Band space is currently available, that availability is rapidly dwindling. As a result brokers are less and less willing to provide transponder time to the "occasional" education buyer but prefer to wait for a major commercial purchaser.
- One of the largest changes occurred when GE Americom purchased all of the GTE satellites and refused to honor any existing contracts. This has driving the pricing on satellites such as the G-Star series up to $600 or $700 per hour.

The changing transponder scene has already had an effect on the education provider. Announcements were made in February 1995 that some providers would be cutting back their curriculum/course offerings beginning the fall semester of 1995. Others are predicting loss of viability within 18 months should remedies not be enacted. The bottom line is that the distance education industry, which relies on fees from schools, cannot compete with the commercial operators, whose revenues are advertiser driven.

There are two solutions to the problem -- one short-term and one long-term. The short-term solution is to provide education providers access to excess governmental capacity, e.g. military satellites. The long-term solution that seems most fiscally responsible is a government loan guarantee for a dedicated education satellite which would be governed and operated by the distance learning providers. Only with such sweeping actions can equal access to education be guaranteed to all of America's citizens.

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THE CHRONICLE of Higher Education.

March 17, 1995 • $2.75
Volume XLI, Number 27

Steep Increase in Satellite Costs Concerns Colleges

By Thomas J. DeLoughry

COLLEGE OFFICIALS involved in distance education warned last week that sharp increases in the cost of satellite time could force them to cancel some courses.

The alert comes at a time when many institutions are considering greater use of distance-learning programs to reach children in schools and adults in community centers and other locations. On some campuses, the efforts have been viewed as less-expensive alternatives to constructing additional classrooms and dormitories.

The cost of satellite time has more than doubled in the last year. Educators and others familiar with the satellite industry say demands for the time have increased among broadcasters, cable companies, and other buyers while the number of devices in orbit has decreased.

TIME IS SCARCE

Even those who are willing to pay the higher prices have difficulty finding time to purchase, as the commercial customers snap it up under long-term contracts.

Groups representing educators involved in distance learning want Congress to authorize the federal government to resell its unused satellite time to schools and colleges. The organizations also want the government to back an effort to launch a satellite that would be dedicated to educational use.

"This is not crying wolf," says Anne Raymond Savage, associate vice-president for academic affairs at Old Dominion University. The price that her university pays for time on a particular type of satellite, known as C band, has risen in the last year to $443 an hour from $186.

Ms. Savage met last week with Old Dominion's provost and engineering dean to discuss the impact of the cost on distance-education programs. "We may have to cut back on the number of engineering courses we offer through that technology," she says.

'DESPERATE CALLS'

The National Education Telecommunications Organization describes the situation as a "crisis." Shelly Weinstein, the group's president, says that owners and users of satellites had predicted the price and shortage problems for several years, but that no one believed they would occur so quickly. Fast-rising demand for time among companies and the failure of a satellite launched in the fall brought things to a head, she says.

"We are getting more and more desperate calls," says Ms. Weinstein, who is also president of EDSAT, a company that helps educators use satellites. "I don't know what we're going to do for them for September of 1995."

The problem has emerged at a time when the Clinton Administration and Congress have focused a good deal of attention on facilitating the growth of data networks—made up of fiber-optic cable—that may someday link homes, schools, and colleges. Educators involved in distance education say such networks will not reach many students for decades and may never be appropriate for connecting with hundreds of locations simultaneously, as can be done with satellites.

Rising costs are not plaguing all distance-learning programs. National Technological University, for example, is such a large user of satellites that it has a 12-year contract for a portion of a satellite, known as a transponder. Officials there say the contract insulates the university from price increases.

The higher costs pose the biggest problem for "occasional users," which include colleges that need small numbers of hours each week to transmit their courses. Colleges that use the C band, an old technology that requires large satellite dishes, have seen the biggest rise in prices, because very few satellites carry C band signals.

Brokers who buy time on satellites for their customers confirm that it is tremendously difficult to find time for occasional users of all kinds, including colleges.

Grace E. Leone, president of IIC Startime Inc. of Los Angeles, says educators must share some of the blame for the troubles they are encountering. Many institutions, she notes, have failed to keep their satellite equipment up to date and therefore cannot benefit from cost saving advances, like digital compression, that enable a broadcaster to use less space on a satellite.

'THEY HAVE TO GET SMART'

Ms. Leone says educators also have not developed consortia that could purchase transponders and then divide the time on them among members. Instead, she says, many individual colleges are in the market trying to buy three hours a week to teach French classes that are nearly identical.

"They cut each other's throats," says Ms. Leone. "They have to get smart and look at this from a businesslike point of view and realize that in unity there is strength."

Ms. Weinstein of the educators group says that schools and colleges have not had the money to invest in new equipment. Some institutions have formed consortia, she says, but duplicate courses will never be eliminated because of competition among educators and a desire among course recipients for choices.

The solution, Ms. Weinstein says, is not to change the behavior of educators, but to designate a satellite for their use. Her group favors the passage of legislation being prepared by Sen. Conrad Burns, Republican of Montana, that would provide federal loan guarantees to companies that build and launch a satellite dedicated to non-profit use.

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(Communications Daily!!)

C-BAND CAPACITY SHORTAGE HITS EDUCATORS, SENDS BROADCASTERS TOWARD FIBER

Many independent educational TV service providers will go out of business because of shortage of domestic C-band capacity and increasing costs of leasing transponders, said Shelly Weinstein, pres.-CEO, National Education Telecommunications Organization and Edsat. For short-term solution, she said, unused capacity that Defense Dept. has leased on commercial satellites could be released to educators at low cost. For long-term solution, she said, Congress should arrange for Commerce Dept. to provide loan guarantee to operator of education-dedicated satellite. She said educators currently spend $400-$500 million per year on transponder fees, and that could approach $2 billion by end of 1990s. "This is not a subsidy; it will pay for itself," she said. "A satellite dedicated to the education market – after 5 to 7 years – would be self-sustaining."

It's difficult for education community to compete with commercial interests for scarce transponder time, Weinstein said, because TV, cable and telephone industries can pay higher fees up front for carriage agreements. Often, she said, educators find their programs preempted because they couldn't afford highest nonpreemptible rates. She said educators can't pay for services in advance, as can private interests. There are 3 reasons educators need their own satellite, Weinstein said: (1) Lower costs. Instead of allowing commercial operators to profit, educators' money could be recycled into their own programs. (2) Equity. Currently educators use either equity-free leases or reseller services, have none of rights of ownership. (3) Stability. Difference in financial abilities and rules of commercial and educational communities leads to preemption.

Proposal has been introduced in previous Congresses by Reps. Morella (R-Md.) and Brown (D-Cal.) to establish education-dedicated satellite by providing loan guarantees for its operation. However, proposal was referred to Education Committees and wasn't attached to bill that passed. Morella aide said proposal could be resubmitted this year. Under last plan, Edsat would be operator of satellite, with responsibilities for raising capital, getting FCC licenses, booking transponders, etc., aide said. Weinstein told us she's still interested in assuming that role: "Our organization can provide low-cost services. [Operator] should be a body that represents the users and providers."

Broadcasters also feel pinch of C-band shortage. Speaking at recent Satellite '95 conference in Washington, Robert Zitter, HBO senior vp-technical operations, said transponder costs haven't dropped but cost of fiber is falling to point of being "nonissue." He warned that if satellites don't increase capacity and reduce costs, they "will be priced out of the market." Brent Stranathan, CBS vp-broadcast distribution, said C-band "crunch" is adding to difficulties in choosing compression technique. He said CBS is "disappointed in the development and speed of compression... MPEG-2 isn't ready, and we may have to look to a higher standard because MPEG 2 may not be good enough." However, he said, inadequate C-band capacity is driving industry for quick solution. Compression will allow more channels in same bandwidth. He agreed that "price is going to be an issue" when comparing satellite with fiber. CBS is looking at fiber feed for coverage of 1998 Olympics in Japan, he said. Other main concern of HBO's Zitter isn't in U.S., but in Asia, where he said orbital congestion and lack of teeth in ITU rules are causing serious problems. Orbital situation, he said, "is unsettling to the equilibrium of the satellite industry, making it very difficult for investors to invest with some measure of certainty."

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James Pagliasotti, Executive Director, 130 State Capitol, Denver, CO 80203
Phone: 303/866-2087 Fax: 303/866-5469

AEROSPACE STATES ASSOCIATION

March 16, 1995

Honorable Conrad Burns
United States Senate
Dirksen Senate Office Building
Washington, D.C. 20510

Dear Senator Burns:

On behalf of Lt. Governor Gail Schoettler of Colorado, Chair of the Aerospace States Association (ASA) and its governor-appointed delegates from 34 member states, I am writing to express our support for a fully interoperable telecommunications system dedicated to education, instruction and training that utilizes satellite-based linkage to terrestrial infrastructure.

As an educational organization, ASA has a long held interest in the efforts of the National Education Telecommunications Organization (NETO), which works to enhance equitable access to educational opportunities for all Americans through a dedicated educational satellite.

We concur with NETO that the current shortage of transponder capacity and high cost of access threatens the ability of America's education entrepreneurs---its colleges, school districts and state agencies---to deliver distance education to a citizenry sorely in need of its services. The distance education industry serves virtually all of our nation's 16,000 school districts. 88 U.S. colleges and universities deliver course work and training at all levels to sites throughout the country and the world. Educators currently spend some $500 million annually on distance education and project that spending will grow to more than $2 billion by the end of the century.

The magnitude of demand for distance education and its critical importance to the well-being of our nation suggests that equitable, reliable and affordable access to satellite-based delivery systems is crucial. Utilization of excess government transponder capacity may be a near-term solution, but ultimately a reallocation of educational monies to establish a satellite dedicated to the education, instruction and training might best serve the American people.

Sincerely,

James Pagliasotti
Executive Director

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[illegible] Communications Industries Report [illegible] published by The [illegible] Group Vol. 12 No. [illegible] SEPTEMBER 1995

COMMUNICATIONS
INDUSTRIES REPORT

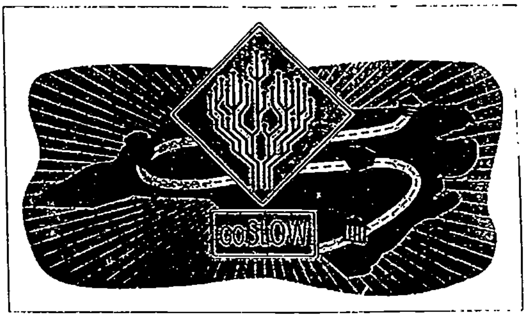

ILLUSTRATION BY [illegible]

SUPERHIGHWAY

North Carolina Superhighway in Slow Gear

The North Carolina Information Highway (NCIH) detours while legislators take time out to study the most efficient use of ATM switching and to revise the way rates are set for video vs data services

By Dick Larsen

Washington DC -- In 1990, North Carolina began to study the feasibility of a broadband network to be built by three phone companies that would bring the state into the 21st century. In 1993, Governor James Hunt announced $4.1 million for the first stages of a "speed of light" superhighway that would eventually connect 3,300 locations such as schools, libraries, medical [illegible] and state offices.

[illegible] their confusion and controversy have ruled the road.

In 1994, the General Assembly withdrew the $4.1 million, concerned about a lack of data on how sites were using funds. Instead, legislators appropriated a one time grant of $7 million for '94-'95. And they recently approved a "Go Slow" measure that curtails additional distance learning sites by allocating $2.5 million to hook up 74 experimental sites through 1996.

An April [illegible] by the State Controller and [illegible] were [illegible] holes in the

See SUPERHIGHWAY, page 4

appendix "b" [illegible]

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SUPERHIGHWAY, *continued from page 1*

ability of the phone companies to "schedule, provide quality connections, resolve troubles and provide accurate billing information....The service providers are using the state as a working model to build a production level service. The state, however, is paying for a production level service."

A Second Look at Distance Learning

Consequently, the '96 funds were earmarked mostly for government offices, medical centers and libraries that will use the NCIH's state-of-the-art ATM switching and SONET technology in order to test applications in addition to distance learning.

The reason: early on, the NCIH's rates were based on the high-end use of two-way interactive video. A distance learning site, such as a school, pays a minimum monthly fee of $4,000 for a maximum of 64 hours of usage, which includes $4,055 for intraLATA charges, $1,544 for interLATA charges and $401 for administrative overhead.

School officials believed the state would pick up a large portion, if not all, of these line charge costs. So they spent initial funds to purchase equipment needed to outfit distance learning labs.

There's concern that unless the rate structure is revised, schools won't have funds for distance learning, even though the technology is in place. Educators also are concerned about the quality of distance learning courses, getting funds to pay for distance learning training, and higher costs of programming that originates outside a school's district.

Meanwhile, a state audit of all potential users showed the "biggest potential use for NCIH sites will be for high-speed data, not video." The auditor concluded that NCIH should "reflect the bandwidth-on-demand principle and immediately develop separate rates for data-only usage for NCIH sites. Each site should be offered a menu of usage choices and should pay according to the amount and type of usage each month."

Problems Early On

Since 1993, an estimated 56 "account paying" sites — primarily schools — are using the network, built by Carolina Telephone, General Telephone and Southern Bell. It is estimated that the phone companies have installed at least four ATM switches. Initially, the project called for installation of 30 ATM switches in three years.

To some, it seemed the state bought a Rolls Royce when it may actually have needed a Volkswagen.

"We believe that two basic mistakes have been made concerning the NCIH," said a report, "North Carolina Information Highway Promises and Problems," by the Washington, DC-based Telecommunications Consulting Group Inc. "The first is not understanding the implications of the truly advanced technology that is being used in this project. The second is assuming that studies and models can be used to 'prove' assertions about the future of the NCIH, instead of relying upon evolving data from real-world experience to guide the project's future direction."

Another problem appears to be confusion about who would pay for the network. "The local schools were told the state would pay, but this didn't happen," said William Carrison, co-author of the report. "As a result of the state audit, the legislature realized that this whole question of pricing has to be re-evaluated."

Another concern, according to a General Assembly analyst who spoke with *CIR*: "You can't put a meter on ATM switching — you can't gage how much to charge for its use. This is a serious problem."

Among the report's findings:

- The regulated phone companies that are building the NCIH are allowed to set rates to recover their monthly expenses, the cost of capital investments and other one-time costs. For high schools, this can be as high as $4,000 a month. Rates and contract terms should be renegotiated with the telephone companies. Also, the state should evaluate competitive procurement of some portions of the NCIH once competitors to the telephone companies can provide such facilities.
- The grants process through which current sites have been funded is lacking. Funding of sites the next three years should be coordinated with operational information according to four application categories: interactive video for distance learning; high-capacity information systems such as what will be required for the state's Criminal Justice Information System; university-related research, particularly in the medical field, and requirements for lower data-rate services.
- Early on, it was assumed that all of North Carolina's telecommunications traffic would be carried on the NCIH network. "We do not believe that all of the state's data and telephone networks can or should be moved to the NCIH, either now or soon," the report said.
- Fundamental questions such as "what can the network do," and "for what can it be sensibly used" are not yet fully addressed. Because of fundamental pricing and cost questions, the General Assembly should have ongoing oversight of and participation in NCIH deployment.

An Overview of the National Education Telecommunications Organization

These are exciting and challenging times. As the nation moves forward on a course for economic growth and productivity for the 21st century, citizens at all economic levels, policymakers and educators are faced with difficult choices. The nation's education systems, are endemic to the nation's economic health and security. Whether officials are reducing the federal deficit, or changing health and defense policies, American education productivity, or the lack of it, will set the pace of economic growth along with the standard and quality of living for Americans for years to come.

Technology has rapidly transformed every sector of our lives--except education. Although telecommunications has turned the world into a global village, America's schools for the most part have remained relatively isolated enterprises. While the educational resources available in this country and around the globe are rich and growing exponentially, the United States is without a technologically integrated telecommunications system available to transport these resources to all children and adults regardless of the wealth and geography of their community.

The plan is to create an integrated nationwide multi-technology infrastructure, a dedicated satellite that links space and existing secondary access roads, i.e., telephone and cable, over which teaching and education resources are delivered and shared with students, teachers, workers and individuals.--A transparent "I-95." The vision is to "wire" together classrooms, workplaces, libraries and other places of learning, nationwide and internationally, through a dedicated telecommunications system, which can be accessed simultaneously through a telephone instrument, a computer, a fax, a video camera and/or a television set. A modern-day "learning-place" for the rural, urban, migrant, disadvantaged and youths at risk to have equal and affordable access to and utilization of educational resources, teaching and learning tools.

NETO/EDSAT is a not-for-profit organization bringing together public officials, K-12 school districts, colleges, educators, government agencies, and public and private education users of telecommunications to aggregate their buying power, and control their own destiny with open, equitable, low-cost and interconnected telecommunication services.

Transportation infrastructures are effective and economical when they provide access to increasingly greater numbers of users and when the primary systems interconnect through multiple secondary transportation systems. America's Interstate Highway system gave the American family access to employment, housing, education and other social benefits which far exceed our greatest expectations and dreams.

Access to information is critical to a knowledge-based enterprise like education. Investments in communications' infrastructure for a global economy is closely tied to the growth and economic viability of the education sector. Of equal importance, the U.S. is left with no other choice than to reshape its schools to become the "crown jewel" of a global democratic society. We must prepare all students, regardless of wealth, geography and population density, to be productive, participating citizens for the challenges they will meet in the 21st century.

We hope you will join those of us who share this vision for the "Information age."

National Education Telecommunications Organization/Education Satellite
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appendix "c" 1

POLICIES and PURPOSES:

The National Education Telecommunications Organization will encourage cooperation and in conjunction with education institutions, states, and territories and other education program providers will establish, as expeditiously as practicable, an education satellite and other telecommunications systems. These systems are to be governed, managed, and operated by a National Education Telecommunications Organization (NETO) as a part of improving equitable and quality instruction and education opportunities for all children and adults. These systems will be responsive to the public needs, education goals of the states and territories, and will contribute to access and utilization of the national education resources.

The National Education Telecommunications Organization, a not-for-profit, non-federal, voluntary organization will help to provide new and expanded telecommunications services as promptly as possible at the national and international levels to all schools, colleges, universities, libraries, and other distance education centers. In implementing this program, care and attention will be directed toward providing such services to all children and adults regardless of their economic status, personal wealth, or the wealth of their community, or their geographic location, as well as those with economic and geographic advantage, toward delivering efficient and economical access and utilization of satellite and other telecommunication services, and toward the reflection of benefits of these technologies in the quality and charges for such services.

NETO will be organized and operated so as to maintain and strengthen instructional and educational opportunities and services in the provision of communications services to states, schools, colleges, universities, libraries, and other distance education centers.

The National Education Telecommunication Organization's primary purposes include equitable, low-cost satellite services, education, training, information and research. Its programs are developed to meet the goals of: (1) improving this country's educational, training and instructional opportunities, (2) improving the opportunities for an equal and quality educational experience for all children and adults, regardless of their geographic location or wealth of the community, and (3) improving access to equal education information for schools, colleges, universities, libraries and other distance education centers.

Services, programs, projects and activities are developed with special care to reach, educate and inform rural and urban schools, migrant students and parents, at-risk students and underserved pupils at all levels of education.

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National Education Telecommunications Organization/Education Satellite
1735 I Street, N.W. Suite 601 Washington, DC 20006 202-293-4211 voice 202-293-4210 fax 800-220-1235 toll free

National Education Telecommunications Organization

Education Satellite

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appendix "c" iii

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University of Colorado
Boulder, Colorado

Tom Stipe
University of Alabama
Tuscaloosa, Alabama

Mark Spear
ALCOA Technical Center
Alcoa, Pennsylvania

Ed Groenhout
Northern Arizona University
Flagstaff, AZ

Shelly Weinstein

President/CEO

National Education Telecommunications Organization/EDSAT

Ms. Weinstein is the President and Chief Executive Officer of the National Education Telecommunications Organization. She has 20 years experience in the supervision and establishment of programs to implement major education, telecommunications, energy, and environmental policies from her work in government, foundations, and the private sector.

Prior to her present position, Ms. Weinstein was Vice President for Communications with the College Satellite Network and served for over five years as director of the Kettering Foundation's Washington, D.C. office.

She was a member of President Carter's "White House Energy Policy and Planning Staff" serving as Special Assistant to James Schlessinger, Assistant to the President. During her tenure, she created, implemented, and mobilized nationwide public participation in the President's national energy plans and policies. This included authorship of the National Energy Plan, Summary of Public Participation for the Executive Office of the President. A charter member of the Department of Energy, Ms. Weinstein served as Director of Environmental Liason.

Ms. Weinstein also served as Director for the Task Force on Citizen Participation, reporting directly to the Secretary of the Department of Health, Education, and Welfare. Her background also includes national and state experience in the fields of school governance. She directed the "Maryland School Finance Study", funded by the Ford Foundation and the Greater Baltimore Commitee of Maryland.

Ms. Weinstein has published extensively and has served as editor and director of a major national review and book on school governance, entitled: Public Testimony on Public Schools (McCutchan Publishing Co. August, 1975).

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appendix "c" v

Genentech, Inc.

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STATEMENT FOR THE RECORD
SUBMITTED BY

GEOFFREY TEETER
SENIOR PROGRAM MANAGER
GENENTECH, INC.

ON

EDUCATIONAL TECHNOLOGY IN THE 21ST CENTURY

BEFORE
THE COMMITTEE ON SCIENCE
AND THE
COMMITTEE ON ECONOMIC AND EDUCATIONAL OPPORTUNITIES
UNITED STATES HOUSE OF REPRESENTATIVES

CONGRESSIONAL HEARING
OCTOBER 12, 1995

INTRODUCTION

Genentech, Inc. appreciates the opportunity to submit the following statement and informational documents to the House Committee on Science and the House Committee on Economic and Educational Opportunities regarding our Access Excellence program in the public schools. Access Excellence is a comprehensive science education program for high school biology teachers. Its major component includes an electronic forum on America Online and a site on the World Wide Web that links high school biology teachers across the country, helping teachers share experiences and knowledge of advances in biotechnology that can be taught to the student "pioneers of tomorrow." We are proud of the results of this cutting-edge public-private partnership.

Genentech is a pioneer biotechnology company that discovers, develops, manufactures and markets human pharmaceuticals for significant unmet medical needs. Genentech's most important asset is its science. The company's research has led to ten of the biotechnology-based products on the market today. It is the only biotechnology company to have taken five of its products from the laboratory to the marketplace. These products include: Activase® (Alteplase, recombinant) to dissolve blood clots to treat heart attacks and strokes; Pulmozyme® (domase alfa) to treat cystic fibrosis; and Protropin® (somatrem for injection) to help children deficient in human growth hormone to grow normally.

Genentech's future and the future of science in America depends on programs like Access Excellence which will inspire the next generation of scientists.

SCIENCE SURVEY

The issue of advancing science education in this country is important; and for the future of our industry, it is crucial. Surveys conducted between 1990 and 1992 led to the creation of the Access Excellence Program described below. These surveys found that:

- only 7 percent of high school seniors are prepared for college-level science courses;
- even our brightest U.S. high school seniors taking advanced placement biology courses scored the lowest among students in 13 countries; and
- U.S. 13-year-olds scored 13th out of students in 15 countries in science achievement.

These startling statistics prompted Genentech to launch an intensive effort to improve the quality of science education in this country through a cutting-edge, on-line forum. This medium successfully integrated technology into the lesson plans of biology teachers in

every state. It also created a model for how technology can be used effectively in the classroom of the future.

This statement focuses on three areas: 1) the Access Excellence program designed to enhance high school biology education; 2) the role of the teacher in the classroom of the future; and 3) the value of public-private partnerships for the advancement of science education.

ACCESS EXCELLENCE

In 1993, Genentech created a national science education program called Access Excellence. The program is funded by a $10 million grant from the company. It enhances high school biology education by linking teachers with one another and with scientists via a forum on America-On-Line and the World Wide Web. The program provides on-line access to colleagues, scientists, and educational resources to help bring current laboratory science into the classroom. Biology teachers share lesson activities, exchange practical information, and teaching strategies, and consult with leading scientists in the public and private sectors to keep current on new scientific discoveries and practical applications. This information advances their curriculum. It transfers relevant practical application of scientific principles to the scientists of tomorrow.

Access Excellence includes an annual one week summit for some of the most innovative high school biology teachers in the country. On the basis of a competitive application, the National Science Teachers Association selects approximately 100 teachers (at least one from each state) to attend an annual summit in San Francisco. There, they receive a laptop computer, a modem, a printer, and intensive training on how to use the Access Excellence Forum on-line. The forum, launched last year, is also available to any teacher with access to a computer, a modem, and America-On-Line or the World Wide Web. All teachers with on-line access are invited to contribute to and benefit from the forum. To our knowledge, this is the first and most developed public-private program of this type in the nation.

The program grew out of ongoing communication and volunteer activities between Genentech employees and local area science teachers. When science teachers were asked what Genentech could do to improve science education, the teachers said they needed a way to "break the isolation" they feel from other science teachers. They wanted to be able to share their teaching ideas and lesson plans with their colleagues. The teachers said it was this rare interaction which allowed them to go beyond standard means of teaching to effectively interest and inspire their students.

One of the most important aspects of the Access Excellence program is its ability to disseminate the innovative work of these highly motivated teachers to the universe of high school biology teachers nationwide. To that end, Genentech provides access to the on-

line network to several hundred additional teachers on a free, six-month trial basis. Genentech also regularly distributes printed versions of selected lesson activities and other science education information from Access Excellence to high school biology teachers nationwide who do not yet have access to computers or on-line services.

THE ROLE OF THE TEACHER IN THE CLASSROOM OF THE FUTURE

Genentech is devoted to fundamentally changing the way students learn and the way teachers teach. Access Excellence goes beyond providing teachers with computers. It provides them with the training necessary to effectively use computers. The program provides an environment in which teachers learn from one another how to best integrate computers into their lesson plans.

However, training does not stop there. The teachers continue this communication system by working together on-line to converse and create a variety of educational projects related to biology. Furthermore, teachers have virtually all required resources available on the Access Excellence electronic forum. A support center is located at Genentech's South San Francisco headquarters staffed by specially trained professionals and volunteer Genentech scientists. This staff answers the technical or scientific questions posed by the teachers in the network.

PUBLIC-PRIVATE PARTNERSHIPS

Access Excellence involves a coordinated effort between Genentech and the National Science Teachers Association. Genentech believes that only through sustained industry participation and public-private partnerships can real change begin to occur in our educational system to move it into the 21st century.

The technology industry, as well as the biotechnology sector, have a very large stake in seeing that our nation's children are well educated and skilled with computers. In order to ensure that our industry has the workers we will need in the future, we must begin now to create an environment in our classrooms which is conducive to innovation and creativity through the use of high tech tools.

School districts cannot implement the changes necessary for transforming the educational system on their own. Each year school districts struggle with budget cuts which reduce scarce resources even further. Industry has the obligation to work with our nation's schools to prepare the next generation for a highly technical job market. Finally, we must however, look beyond the traditional industries, i.e., hardware and software companies, and communications companies to companies like Genentech and others with substantive knowledge to bring business experience with technological integration and innovation directly into the classroom.

CONCLUSION

The Access Excellence program will be entering its third year in 1996. Genentech is currently looking for ways in which to expand the program to include elementary school grades and other scientific disciplines like chemistry and physics. Partnerships with other industries and governmental entities must be created to help this experiment grow.

Industry should take the lead in forging constructive public-private partnerships. With an investment of approximately $3 million per year, Genentech has been able to reach out to and link thousands of biology teachers. More than 5,000 teachers participate on the Access Excellence network every day. These teachers report that their professional world has expanded and that their students are more excited about learning.

Genentech remains committed to its Access Excellence program. Through future cooperation with partners in the public and private sectors, we hope the Access Excellence example can reach thousands more high school science students and help develop the future scientists of America.

Thank you for the opportunity to present our views and experiences.

ACCESS EXCELLENCE
GENENTECH

-- Program Backgrounder --

Access Excellence is a national educational program that provides high school biology teachers access to peers, scientists, and critical sources of new scientific information via the Informatic · Highway.

Access Excellence grew out of ongoing communication and volunteer activities between Genentech employees and local area science teachers. When science teachers were asked what Genentech could do to make an impactful change in science education, the teachers said they needed a way to "break the isolation" they feel from other science teachers and be able to share their teaching ideas and lesson plans with their colleagues. They said it was this rare interaction which allowed them to go beyond standard means of teaching to effectively interest and inspire their students.

Guided by a blue-ribbon panel of educational and scientific advisors, *Access Excellence* is dedicated to enhancing biology teaching by providing a computer network forum on which teachers can share their innovative teaching ideas and lesson activities and access information, expert assistance, and the advice and experience of other teachers to create new ideas.

Here's how it works:

Under the auspices of the National Science Teachers Association (NSTA), 105 of the most motivated high school biology teachers from every state and Puerto Rico were selected as *Access Excellence* Fellows in the first year of the program. This year, an additional 104 people have been selected by NSTA. Each of the teachers receive a free laptop computer with modem and printer and a subscription to America Online, an interactive computer network.

- more -

460 Point San Bruno Boulevard • South San Francisco, CA 94080 • 1 800 [illegible]

In addition, the teachers attend the *Access Excellence* Summit in San Francisco. At the Summit, the teachers become acquainted with one another, learn how to use the laptop computer and online network, and are exposed to information and activities that go beyond traditional education conferences.

But the interaction doesn't stop there. The teachers continue this valuable ongoing communication by working together to converse and create on a variety of educational projects related to biology.

One of the most important aspects of the program is its ability to disseminate the innovative work of these highly motivated teachers to the universe of high school biology teachers nationwide. To that end, we provide access to the online network to several hundred additional teachers on a free, six-month trial basis. We will also regularly distribute printed versions of selected lesson plans and other information from *Access Excellence* to high school biology teachers nationwide.

The teachers have virtually all the resources they desire made available on the *Access Excellence* electronic forum and a support center located at Genentech's South San Francisco headquarters staffed by specially trained professionals and volunteer Genentech scientists.

Genentech, Inc., sponsor of *Access Excellence*, is a leading international biotechnology company that discovers, develops, manufactures and markets human pharmaceuticals for significant unmet medical needs.

Access Excellence reflects the company's commitment to improving science education in America. Teachers who are interested in participating in the program should contact the Access Excellence staff toll-free at 1-800-295-9881.

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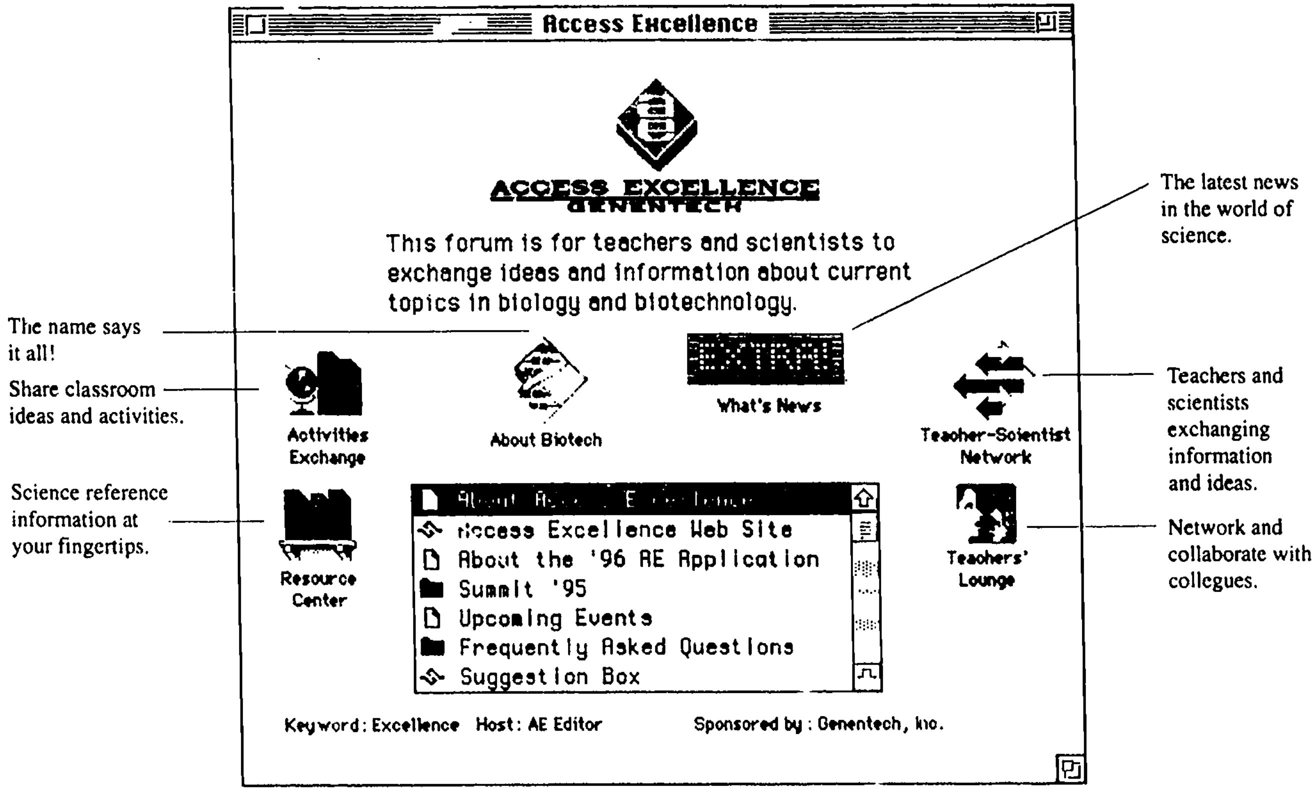
Access Excellence
ACCESS EXCELLENCE
GENENTECH
This forum is for teachers and scientists to exchange ideas and information about current topics in biology and biotechnology.
Activities Exchange
About Biotech
What's News
Teacher-Scientist Network
Resource Center
Teachers' Lounge
Access Excellence Web Site
About the '96 AE Application
Summit '95
Upcoming Events
Frequently Asked Questions
Suggestion Box
Keyword: Excellence Host: AE Editor
Sponsored by: Genentech, Inc.
The name says it all!
Share classroom ideas and activities.
Science reference information at your fingertips.
The latest news in the world of science.
Teachers and scientists exchanging information and ideas.
Network and collaborate with collegues.

/THE LAST WORD Bio/Technology September 1995

Online Education Program Helps Teachers Teach Science

Geoff Teeter

Geoff Teeter is senior program manager of the Access Excellence program at Genentech, Inc. (e-mail: teeter.geoffrey @gene.com) Scientists interested in participating in America Online should contact him by e-mail

As more biotechnology companies reach profitability, more of you will start considering ways in which you can contribute to your community in a way that reflects the culture of your company and the needs of our industry. As you do so, I recommend you consider two factors.

First, evaluate what your employees are already doing on their own. Any effort you undertake as a company will be considerably easier and more effective if it has the backing and enthusiastic support of your employees. At Genentech, while our employees have been involved in a wide variety of community efforts, from beach cleanup to youth mentoring, a common effort among our primarily scientific staff has been in the area of science education—and it is from that foundation that we launched a comprehensive national effort called Access Excellence. I suspect many of you may find a similar interest among your employees.

Second, consider science education and its importance to your business. Effective education in the sciences is lacking in many communities: In a recent U.S. Department of Health and Human Services (Washington, D.C.) survey, high school seniors scored the lowest in advanced placement biology out of 13 countries. Yet effective education in the sciences, particularly the life sciences, is tremendously important for the entire biotechnology industry.

Obviously, we need to have continually available a pool of scientists from which to hire. But we also need many more people other than scientists. At most biotechnology companies, whether recruiting a lawyer, a plant manager, an administrative assistant, or a human resources specialist, you typically need employees who have at least a general understanding of and appreciation for the life sciences.

For all these reasons and more, it makes sense for any biotechnology company to contribute to improving science education in this country. Genentech thinks it makes perfect sense. Launched in October 1993, Access Excellence is a $10 million national education program for high school biology teachers. The program centers around a communications network on America Online and the internet's worldwide web. It provides online access to colleagues, scientists, and educational resources to help bring current laboratory science into the classroom.

Genentech developed Access Excellence systematically. Once we decided to get formally involved in science education, we determined how to get involved based on direct feedback from teachers themselves. Much of our information came from a survey we conducted in 1993 to determine secondary school teachers' specific needs and the obstacles they faced. The majority of responding teachers stated that they felt isolated from their peers and the latest scientific information and, as a result, were often using out-of-date curricula and teaching methods in the classroom.

Through Access Excellence, biology teachers all over the U.S. have access to an online forum that provides lesson activities from other teachers across the country, a bulletin board to post and source teaching strategies, monthly science seminars led by teams of teachers and scientists, and a support center staffed by computer and science professionals.

By placing the Access Excellence hub online, Genentech was simply applying the best available tools to the task, an approach that is both effective and highly encouraged. In fact, U.S. Vice President Albert Gore has recognized the Access Excellence program, stating in reference to it that "the development of the information superhighway is vital to [American] education and economic development." As testament to the program's success, during the recent Ebola outbreak in Zaire, Access Excellence received more than 40,000 hits in one day, making it one of the most active sites on the internet at that time. Many biology teachers log on before school to review up-to-date scientific news that they can share with their students that day.

Access Excellence includes an annual one week summit for some of the most innovative U.S. high school biology teachers. On the basis of competitive application, the National Science Teachers Association (Arlington, VA) selects approximately 100 teachers to attend the summit, where the teachers receive a laptop computer, a modem, a printer, and intensive training on how to use the Access Excellence Forum online. By holding these annual summits and by involving highly motivated teachers from all over the country, we believe teachers will spread this news to colleagues: Access Excellence is an important resource for high school biology teachers. And teachers can act on that news: The Access Excellence online forum is available to any teacher (or anyone else) with a computer, a modem, and access to America Online (keyword: excellence) or the worldwide web (http//www.gene.com/ae).

The beauty of targeting science education is that you do not have to wait until you reach profitability to make an impact, particularly with tools like the internet available. As a start, encourage and assist in the efforts your employees may already be making. Small initial efforts could be a perfect springboard for a more comprehensive program that your employees can rally behind and that your whole company can take pride in, as Genentech does in Access Excellence. Who knows where it could lead? ///

USA Today

October 4, 1995

Science teachers gain Access in cyberspace

By Anita Manning
USA TODAY

When her students pose a problem she can't immediately solve, teacher Nancy Ridenour, chair of the science department at Ithaca (N.Y.) High School, can turn to hundreds of others for instant advice.

She does it through a computer network called Access Excellence. The network, a $10 million project of the biotechnology company Genentech, was designed to help science teachers keep on top of new developments, and even more important, to help them connect with each other.

Before beginning the project, Genentech surveyed science teachers to find out what they need most. Ninety-two percent of the more than 300 polled said they "feel isolated from other teachers across the country" and wish there were an easy, convenient way to exchange ideas.

Enter Access Excellence. The program opens a world of information to teachers, from the latest on DNA fingerprinting to the hot news on the latest scary virus. Its greatest value, says Ridenour, is that it sparks the minds of teachers. "It's important to energize teachers," she says, because "when teachers are energized the students get the benefit."

While the network is aimed at teachers, anyone with a computer and modem can get into it. Says Ridenour, "One of my students the other day said, 'Hey, I got into all these files on biology and the human genome project, and that's what I want to major in in college.'"

Ridenour was among the first 100 teachers to win fellowships from Genentech, which for the past two summers has brought teachers from every state to the company's San Francisco headquarters. Fellows identified by the National Science Teachers' Association as those most likely to play a leadership role in their school communities, spend a few days meeting scientists and learning about Access Excellence. They're each given a modem-equipped laptop computer and unlimited time on America Online. The idea, says Genentech's Geoff Teeter, is to "generate catalysts for the program, people to guide it."

"Our main focus is to prove our hypothesis that by helping teachers break through the isolation they experience, to inspire them and help them inspire students in a new way, they'll effect a change in science education."

What's in it for Genentech? Not a thing, Teeter says, "other than getting a scientifically literate population — and years down the line, helping to generate future scientists."

Lots of people are interested. About 10,000 entries a month into the forum have been charted through America Online, and 2,000-5,000 a day through the World Wide Web is "about average," says Teeter.

For teachers, it's a "powerful tool," says Ridenour. At a summer institute for high school biology teachers she coordinated last summer at Cornell University, one of the attendees was a teacher from fire-plagued Long Island who asked for information on burned-out ecosystems. Ridenour posted a query on the Access Excellence teachers' bulletin board and "I must have had 15 responses right away," she says. "It was amazing. It's like having a community of colleagues out there."

On-line menu of resources

Teachers who have access to a computer and a modem can tap into Access Excellence through American Online in the educational section's Teacher Information Network (keyword: Excellence), or the Internet's Worldwide Web at http://www.gene.com/ae. Here's what you'll find:

▶ **Activities Exchange.** Lesson activities and teaching strategies for the classroom.

▶ **What's News.** Summaries of science news culled from journals and conventions; interviews with scientists; fun facts to take into the classroom.

▶ **Teacher-Scientist Network.** On-line discussions and seminars hosted by teams of teachers and scientists on topics of interest.

▶ **Resource Center.** Meeting and convention schedules, competitions, exhibits, good books, information on national organizations for science teachers.

▶ **Teachers' Lounge.** Message boards where teachers can post questions and answers on everything from "How to conduct a science fair" to "How to keep the 6th period awake."

▶ **About Biotech.** Careers in biotechnology, historical perspective and a look at current biotech discoveries.

You don't have a computer? Call 800-295-9881 for copies of lesson activities and other information.

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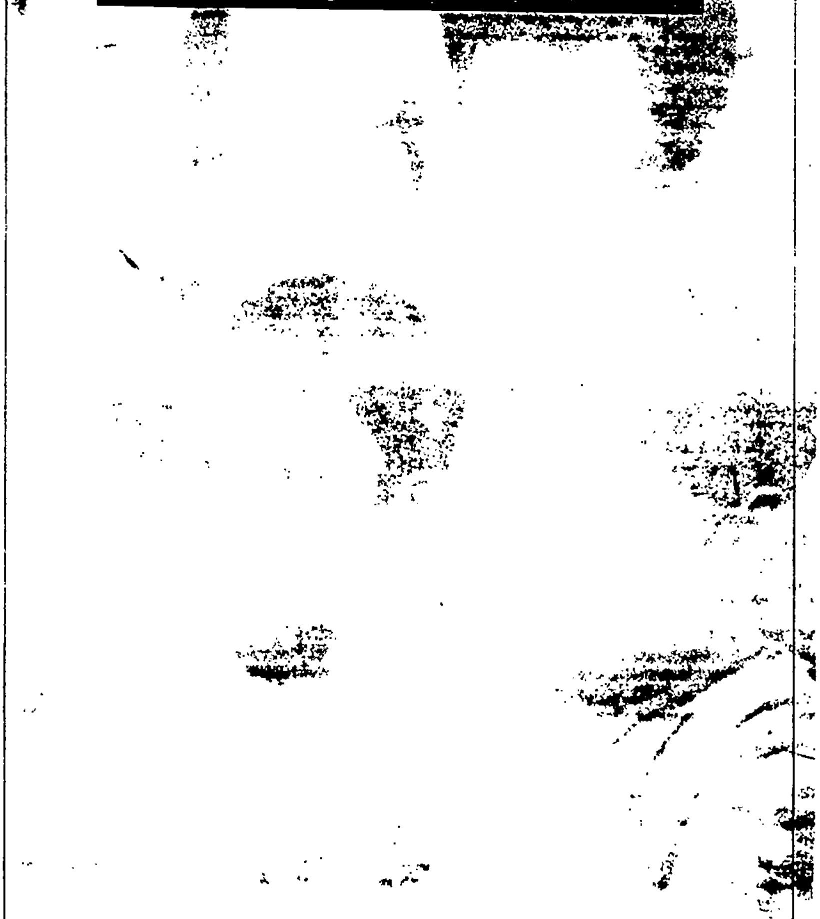
Teachers & technology
making the connection



OFFICE OF TECHNOLOGY ASSESSMENT ■ CONGRESS OF THE UNITED STATES

Summary and Policy Options 1

SUMMARY OF KEY FINDINGS

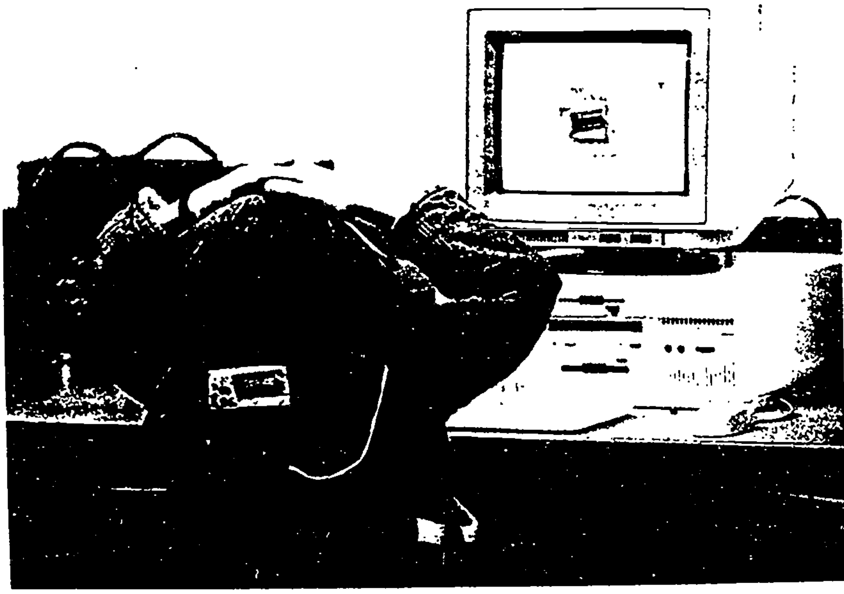
- Projections suggest that by spring 1995, schools in the United States will have 5.8 million computers for use in instruction—about one for every nine students. Almost every school in the country has at least one television and videocassette recorder, and 41 percent of teachers have a TV in their classrooms. Only one teacher in eight has a telephone in class and less than 1 percent have access to voice mail. Classroom access to newer technologies like CD-ROM and networking capabilities are also limited. While 75 percent of public schools have access to some kind of computer network, and 35 percent of public schools have access to the Internet, only 3 percent of instructional rooms (classrooms, labs, and media centers) are connected to the Internet.
- Despite technologies available in schools, a substantial number of teachers report little or no use of computers for instruction. Their use of other technologies also varies considerably.
- While technology is not a panacea for all educational ills, today's technologies are essential tools of the teaching trade. To use these tools well, teachers need visions of the technologies' potential, opportunities to apply them, training and just-in-time support, and time to experiment. Only then can teachers be informed and fearless in their use of new technologies.
- Using technology can change the way teachers teach. Some teachers use technology in traditional "teacher-centered" ways, such as drill and practice for mastery of basic skills, or to supplement teacher-controlled activities. On the other hand, some teachers use technology to support more student-centered approaches to instruction, so that students can conduct

ANDREW M. LEVINE

Helping teachers become "fearless" with technology could be the best way to assure that they use these tools effectively in their classrooms

their own scientific inquiries and engage in collaborative activities while the teacher assumes the role of facilitator or coach. Teachers who fall into the latter group are among the most enthusiastic technology users, because technology is particularly suited to support this kind of instruction.

- Increased communications is one of the biggest changes technology offers classroom teachers. Telecommunications, from simple telephones to advanced networks, can transcend the walls of isolation that shape the teaching profession and allow teachers to converse and share experiences with colleagues, school administrators, parents, and experts in the field.
- Helping teachers use technology effectively may be the most important step to assuring that current and future investments in technology are realized.
- Most teachers have not had adequate training to prepare them to use technology effectively in teaching. Currently, most funds for technology are spent on hardware and software, but experienced technology-using sites advocate larger allocations for training and support. On average, districts devote no more than 15 percent of technology budgets to teacher training. Some states have suggested this figure should be more like 30 percent.
- A majority of teachers report feeling inadequately trained to use technology resources, particularly computer-based technologies. Although many teachers see the value of *students* learning about computers and other technologies, some are not aware of the resources technology can offer them as professionals in carrying out the many aspects of their jobs.
- Although schools have made significant progress in helping teachers to use basic technological tools such as word processing and databases, they still struggle with integrating technology into the curriculum. Curriculum integration is central if technology is to become a truly effective educational resource, yet integration is a difficult, time-consuming, and resource-intensive endeavor.
- Technology can be a valuable resource for improving teacher education overall. It can bring models of the best teaching live from the classroom into the colleges of education, or provide video case studies of teaching styles and approaches. It can forge stronger connections among student teachers, mentor teachers in the field, and university faculty.
- Despite the importance of technology in teacher education, it is not central to the teacher preparation experience in most colleges of education in the United States today. Most new teachers graduate from teacher preparation institutions with limited knowledge of the ways technology can be used in their professional practice.
- The federal government has played a limited role in technology-related teacher development compared with states, universities, and school districts. Even so, past federal programs have piloted innovative educational applications of technology for teachers by providing significant support for professional development, specifically among mathematics, science, and special education teachers, and by providing funding for technology-related professional



CHRIS HARDY SAN FRANCISCO EXAMINER

Technology is a fact of life in today's society and students will need to be facile with these powerful tools. This young student makes sure his thinking cap is on as he ponders a computer screen in the classroom.

development in school districts that could not have supported it on their own.

- The federal government has tended to focus more on inservice than preservice education, channeling more support to K-12 schools than to colleges of education—an approach that may address current needs but does not greatly influence teacher preparation or quality over the long term.
- The federal government has a unique opportunity to encourage greater links between technology and professional development, through recent legislation such as Goals 2000 and the Improving American's Schools Act. The way the laws are currently written, however, funding for technology and teacher training, and support for effective use, may not be high priorities. National leadership for educational technology can create enthusiasm and support for state and local technology initiatives. Focusing attention, as well as funding, on how technologies can support professional development, and on how teachers are essential to the implementation of technologies, can send important signals to schools around the country.

INTRODUCTION

"A teacher affects eternity; he can never tell where his influence stops."

Henry Adams, from *The Education of Henry Adams*

Technology is a fact of American life. Computers, video, television, telephones, radio, and telecommunications networks exert an incalculable influence on how we live, work, and play—an influence likely to expand as hardware and software become more powerful, affordable, and per-

vasive.[1] New technologies are already essential tools for doing business and are quickly becoming a primary means for people to acquire information. For example, in 1993 an estimated 12 million-plus Americans regularly used electronic mail and related online information services.[2] By October 1994, the number of e-mail users was estimated to be more than 27 million.[3]

For students, the ability to use technology has come to be recognized as an indispensable skill. The Secretary's Commission on Achieving Necessary Skills (SCANS) stated this in the starkest terms, "Those unable to use . . . [technology] face a lifetime of menial work."[4]

Recognizing their responsibility to prepare students to work and live in a technological society, states and school districts have adopted standards for teaching students with and about technology.[5] For example, in a 1994 survey conducted for the Office of Technology Assessment (OTA), all but seven states reported that they require or recommend integrating computers or information technology into the curriculum, and 19 states require seniors to demonstrate computer competency before graduating.[6] The question now is, how can schools use technology more effectively?

Most policy discussions and technology initiatives have tended to focus on hardware and software acquisition, and student access to technology. However, in the enthusiasm to get technology to students, and in the context of limited resources, teacher issues have been shortchanged. When teacher needs are discussed, the emphasis is often on providing short-term training to familiarize teachers with a specific application or encourage general computer literacy. Seldom have policy discussions or initiatives centered on the relationship between technology and the teacher's role. Seldom have they articulated a vision of how technology can empower teachers to carry out all parts of their jobs.

In response to these concerns, noted as issues in earlier OTA reports,[7] OTA was asked to do this study by congressional committees and members of Congress with interests in the application of emerging technologies to education (see box 1-1).

In addition to the usual OTA process of convening an advisory panel, conducting extensive staff work, and obtaining broad peer review of drafts, OTA used a variety of methods to conduct this assessment (see box 1-2). The technologies OTA focused on and their current availability in the nation's elementary and secondary schools are described in box 1-3.

OTA finds the lack of attention to teachers and technologies ironic, for at the cent of effective use of instructional technologies are those who oversee the daily activities of the classroom—the teachers. **To use new technologies well, teachers**

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[1] See, e.g., U.S. Congress, Office of Technology Assessment, *Electronic Enterprises: Looking to the Future*, OTA-TCT-600 (Washington, DC. U.S. Government Printing Office, May 1994).

[2] J. Eckhouse, "Internet: Millions of Users Plug in to Hug Computer Network," *San Francisco Chronicle*, June 1, 1993, pp. C-1, C-7

[3] Matrix Information and Directory Services, Austin, TX, October 1994.

[4] *What Work Requires of Schools: A SCANS Report for America 2000*, Secretary's Commission on Achieving Necessary Skills (Washington DC U S. Department of Labor, June 1991), p. 15.

[5] For this study, when the term *technology* is used, it refers to all forms of computers and their peripherals including hard disk drives, printers, CD-ROM, projection devices, and networks offering telecommunications linkages. It also refers to a range of other new or more traditional technologies: telephones, video cameras, televisions and VCRs, fax machines, videodiscs, cable and other one- or two-way links, small devices like electronic calculators, personal digital assistants or other hand-held devices, or combinations of these and other new technologies.

[6] Ronald E. Anderson, "State Technology Activities Related to Teachers," contractor report prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, Nov. 15, 1994.

[7] U.S. Congress, Office of Technology Assessment, *Power On! New Tools for Teaching and Learning*, OTA-SET-379 (Washington, DC U S Government Printing Office, September 1988); and *Linking for Learning A New Course for Education*, OTA-SET-430 (Washington, DC. U S Government Printing Office, November 1989).

BOX 1-1: Why This Study?

In 1986, Congress asked the Office of Technology Assessment to study the use of computers in schools. In 1988, OTA reported its findings in *Power On! New Tools for Teaching and Learning*,[1] which described the promise of and barriers to using technology[2] in K-12 education. At that time, there were about two million personal computers in American schools, a ratio of roughly one computer for every 30 students. Most educational software was limited to drill-and-practice applications. A handful of small, special-purpose educational software publishers were scrambling to create a market for their products. Schools were focusing attention on teaching students "computer literacy" skills. Teacher training consisted of general computer awareness courses, and a few adventurous souls were learning to program in BASIC or LOGO, so they could design their own software applications. At that time, most teachers did not use computers as a significant part of their teaching—only half the K-12 teaching force reported using computers in instruction. Few teachers had computers of their own at school or at home. Not surprisingly, many teachers were less than impressed with this new wave of educational euphoria.

Similarly, in 1989 when OTA released *Linking for Learning: A New Course for Education*,[3] a followup report assessing how schools were using distance-learning technologies to link students and teachers with resources, activity was limited. At that time, states were beginning to invest in broadcast, microwave, satellite, cable, and computer-based systems, and the federal Star School Project had just funded its first round of projects. In subsequent work assessing technologies for testing[4] and adult literacy,[5] OTA reported on emerging opportunities presented by technology.

In each of these reports to Congress OTA noted the critical role of teachers. To learn more about how schools and teachers use computers and other technologies and what this means for future policies, in the summer of 1993 Congress requested OTA to revisit the issue of teachers and technology in K-12 schools in depth.

Requesters, and their affiliations during the 103d Congress are as follows:

U.S. Senate

Committee on Labor and Human Resources
Edward M. Kennedy, Chairman[6]
Committee on Appropriations
Thad Cochran, Member

U.S. House of Representatives

Committee on Education and Labor[7]
William D. Ford, Chairman[8]
William F. Goodling, Ranking Minority Member[9]
Subcommittee on Elementary, Secondary, and Vocational Education[10]
Dale E. Kildee, Chairman[11]

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[1] U.S. Congress, Office of Technology Assessment, *Power On! New Tools for Teaching and Learning*, OTA-SET-379 (Washington, DC: U.S. Government Printing Office, September 1988).

[2] The main focus of that report was the personal computer, whether as a stand-alone unit, connected to a local area network, or as part of a more comprehensive integrated learning system.

[3] *Linking for Learning: A New Course for Education*, OTA-SET-430 (Washington, DC: U.S. Government Printing Office, November 1989).

[4] *Testing in American Schools: Asking the Right Questions*, OTA-SET-519 (Washington, DC: U.S. Government Printing Office, February 1992).

[5] *Adult Literacy and New Technologies: Tools for A Lifetime*, OTA-SET-550 (Washington, DC: U.S. Government Printing Office, July 1993).

[6] Now Ranking Minority Member.

[7] Now the House Committee on Economic and Educational Opportunities.

[8] Now retired.

[9] Now Chairman, House Committee on Economic and Educational Opportunities.

[10] Now the House Subcommittee on Early Childhood, Youth, and Families.

[11] Now Ranking Minority Member.

(continued)

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BOX 1-1 (cont'd): Why This Study?

The requesters asked OTA to look at several issues. Do teachers use technology in their teaching? Why? What happens when they do? Why don't more teachers use technology? How do teachers learn about technology? Are prospective teachers being prepared to use technology before entering the classroom? Which factors influence implementation of technology across schools and districts? What roles do schools, districts, states, and the federal government play in helping teachers adjust to the challenges and opportunities presented by new technologies? This report describes the results of OTA's research into all of these questions.

The issue of teachers and technology is of continuing relevance to the 104th Congress. Two major pieces of legislation passed in the 103d Congress have provided authorization for a number of initiatives related to technology. The decisions made by the 104th Congress will shape the direction of these initiatives. The Goals 2000: Educate America Act encourages states to undertake ambitious school reform efforts and funds statewide plans for using technology to achieve these reforms. The Improving America's Schools Act, in a revised Title III of the Elementary and Secondary Education Act (ESEA), contains the most comprehensive legislation for educational technology ever passed by Congress and places a greater emphasis on teacher professional development in several other federal programs. These two laws have the potential to bring more coherent and consistent leadership to the federal role in technology and teacher development, but whether this occurs will depend on how the programs are funded and implemented. This report contains discussion of issues and policy options relevant to implementation.

In addition to funding decisions about current education programs, the 104th Congress faces other issues affecting education technology, most notably legislation to update the Communications Act of 1934. The availability and affordability of telecommunications technologies for schools are two of the most important issues affecting the future of educational technology.

not only need access to them, but they also need opportunities to discover what the technologies can do, learn how to operate them, and experiment with ways to apply them. For teachers to make informed choices and wise uses of technology, they must be literate and comfortable with a range of educational technologies.

However, the use of technology in teaching, like any other change to the status quo, should be considered in light of the unique characteristics of the teaching profession. Indeed, teaching has been called many things: an art, a science, a calling, a way of life. Throughout history, teachers have taken up the tools at hand to help them teach—whether marking on clay with a stylus, or writing on a blackboard with chalk. As new technologies have emerged—photography, filmstrips, radio, television—teachers have used them to extend the range of what they could teach, illustrate ideas in different ways, bring new materials to students, and motivate learners.

The process of adopting new technologies has never been quick or effortless, however. Like all professionals, teachers have instructional methods, teaching styles, and working procedures that have served well in the past and that often reflect how they themselves were prepared. And like other large institutions, schools have organizational characteristics that make change difficult. Moreover, the unique culture of schools and changing public expectations for them create conditions substantially different from those of other workplaces.

Although teachers want to enlist all available tools to help their students learn, as new technologies have become more sophisticated, the transition has become even harder, requiring more training before teachers can use them effectively. Teachers, like many in society, can find themselves bewildered by the changing landscape of computer, video, and telecommunications technologies. Many are made skeptical by predictions

BOX 1-2: How This Study Was Conducted

Although considerable research has been conducted since 1988 on student uses of technology, far less has been done on teacher uses, and consequently data on teacher issues are limited. As a starting point for this study, OTA reviewed research on teachers and technology, including national surveys and studies, evaluations of federal technology-related programs, and research on state, district, and school technology efforts.

During the course of this study, OTA staff made site visits to schools of all grade levels across the country (see appendix E), and had hundreds of conversations with teachers, researchers, and administrators—in classrooms, at meetings and conferences, and over the telephone and electronic mail. OTA also convened two focus groups of teachers and held a workshop about lessons from research projects on technology in schools.

OTA also drew upon a range of other sources. Much of the background information for the study came from research contracted by OTA (see appendix F), including a series of in-depth interviews with average teachers regarding their experiences with technology,[1] a survey of faculty and recent graduates of colleges of education regarding technology use in preservice teacher education,[2] a research review of telecommunications networks,[3] and a review of past and current federal programs and support for teacher development and technology.[4] A series of OTA-contracted case studies looked at exemplary approaches to training teachers about technology use at the preservice and inservice level.[5] OTA contracted for two other research reviews, an analysis of trend data from several surveys about school acquisition and use of new technologies,[6] and a review of state policies related to technology in K-12 education.[7]

Some of these research strategies yielded statistical data. Others produced information that was mostly descriptive or anecdotal on such issues as teachers' perceptions of the role of technology in their teaching and the factors that encourage or inhibit their technology use. By combining quantitative and qualitative information, OTA has tried to present a multifaceted picture of teacher experiences with technology

As with all OTA reports, the project was guided by an advisory panel made up of experts and stakeholders in the field, teachers, principals, and district, state, and school board personnel, college of education faculty, representatives of teacher unions and professional organizations, hardware, software, and business representatives; and telecommunications and media experts. The advisory panel met twice, at the beginning of and near the end of the research phase of the project, and helped define the research questions and interpret the information. In addition, dozens of individuals reviewed drafts of and contributed to this study (see appendix D). Although every panel member and reviewer may not agree with all the findings or policy options in this report, the panel's and other reviewers' guidance and direction were critical in shaping its final form.

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[1] Belinda Griffith, "Technology in Schools: Hearing from the Teachers," Office of Technology Assessment, contractor report, October 1993.

[2] Jerry Willis et al., "Information Technologies in Teacher Education: Survey of the Current Status," Office of Technology Assessment, contractor report, March 1994.

[3] TERC, "Review of Research on Teachers and Telecommunications," Office of Technology Assessment, contractor report, May 1994

[4] Nancy Kober, "Teachers and Technology: The Federal Role," Office of Technology Assessment, contractor report, May 25, 1994

[5] John R. Mergendoller et al., "Case Studies of Exemplary Approaches to Training Teachers to Use Technology," Office of Technology Assessment, contractor report, May 1994.

[6] Henry J. Becker, "Analysis and Trends of School Use of New Technologies," Office of Technology Assessment, contractor report, March 1994

[7] Ronald E. Anderson, "State Technology Activities Related to Teachers," Office of Technology Assessment, contractor report, Nov 15, 1994

promising that new technologies will reform education and change schools as we know them.

Making the connection between technology and teachers—helping the 2.8 million teachers in public and private kindergarten-through-twelfth-grade (K-12) schools effectively incorporate technology into the teaching and learning process—is one of the most important steps the nation can take to make the most of past and continuing investments in educational technology. It is central to the ultimate goal fostered by these investments: not just helping students become competent users of technology, but helping them become more accomplished learners overall.

This report seeks to underscore the connection between teachers and effective implementation of technology in schools.

TEACHING AND TECHNOLOGY: THE POTENTIAL

"You wouldn't want a doctor to remove your gall bladder without the latest technology and the skill to use that technology, would you? It's the same with teaching. [Teachers need tools, skills]. . .it's a profession."

Rusty Sweeny, algebra teacher, Piscataquis Community High School, Guilford, ME

OTA has seen the promise of technology come to light in school districts throughout the country, where many teachers are using technology to teach their students. Some have found it to be a catalyst to support school reform, stimulate new teaching methods, and even redefine the role of teachers. But it is not only in the realm of direct student contact that technology has benefited these teachers. Many other aspects of a teacher's job—preparing materials, developing lessons, assessing student progress, enlisting parent participation, keeping up with advances in pedagogy and content, and participating in the professional community—can be accomplished with technology, often more easily and efficiently. When teachers discover ways that technology can strengthen their teaching, help them carry out administrative tasks, and enrich their professional growth, technology starts to make sense to them. It can be a resource for improving the preparation of new teachers as well. However, there are also many teachers who have not seen this potential, teachers whose use of technology is marginal, limited, and unenthusiastic. The stories and experiences of both these groups suggest lessons for policymakers. Table 1-1 summarizes the potential that technology offers to schools and teachers.

Improving Teaching with Technology

OTA has found many examples throughout the nation of how technology can help teachers with all parts of their jobs. First and foremost, teachers want to ensure that their students are learning. If technology can be a resource to enhance student achievement and interest in learning, teachers are more likely to invest the time and energy to learn to use it in their teaching. However, the relationship between technology and student learning is too often framed as a seemingly simple question: is teaching with computers and other technologies better than teaching without them? Clearly, computers "cannot change leaden instruction into gold,"[8] and there remain numerous questions about how, when, and how well alternative technologies contribute to student learning and achievement. Issues related to measuring the impact of various approaches to teaching, including the use of new technologies on student learning are complicated and beyond the scope of this study (see box 1-4). This report's analysis of the potential of technologies for improving teaching and learning focuses on two aspects of the teaching-learning continuum: teachers' perceptions of how new technologies help them improve their instruction and how they see their classrooms changing as a result.

Many technology-using teachers find that technology can help them improve student learn-

[8] James Bosco, Western Michigan University, personal communication, August 1993

BOX 1-3: Technologies in U.S. Schools: Definitions and Availability

What are the technologies available in U.S. schools today and how are they used? Following is a brief outline of some technologies found in schools and the potential impact of those technologies on teachers and students

Computers

A *computer* is a programmable, electronic machine that can store, retrieve, and process data. Desktop computers are sometimes called microcomputers because they have a single integrated circuit known as a microprocessor

During the last three years, the total number of computers in schools has risen by about 18 percent annually and, based on those projections, there will be an estimated 5.8 million computers in U.S. schools by spring 1995. That translates to approximately one computer for every nine students. There is enormous variability in student-computer ratios (*computer density*) from school to school and across states. The greatest disparities are found between small schools (enrollments of 300 or less) and large schools (enrollments of 1,000 or more), schools with fewer students tend to have more computers per student

Still, sheer numbers of computers do not indicate real access or use. For example, although 35 percent of all U.S. public schools have access to the Internet, only 3 percent of instructional rooms (classrooms, labs, and media centers) are connected. Many factors dictate technology use, but the age and power of the technology seems to be a prevalent influence in K-12 schools. As of 1992, one-half of the computers used for K-12 instruction in the United States were older, less-powerful Apple II models, yet most software and applications currently being developed today cannot run on these machines.

Two-Way Communications

Two-way communications that allow teachers and students to share and receive ideas with others outside their immediate classroom are an important aspect of telecommunications networking. For basic two-way communications, *telephones* and *modems* are staple equipment. Currently, though, only one teacher in eight has a telephone in the classroom that can be used for outside calls. In addition, less than 1 percent of teachers with telephones have access to voice mail, which is a useful tool to leave or retrieve messages when parents, administrators, or other teachers are hard to reach during the school day.

A *modem* is a device that allows computers to communicate electronically across telephone lines by converting digital computer signals into analog format for transmission. In recent years, schools have begun installing more modems for teacher use. In 1989 one-fourth of U.S. schools had a modem that could be used by teachers or students, and by 1992 the figure had grown to 38 percent of all schools, although more high schools (60 percent) had modems than middle schools (35 percent) or elementary schools (33 percent)

Telecommunications Networking

Telecommunications networking includes the Internet and other means of accessing shared communications systems that support digital communications among connected computers.

Local area networks (LANs) link computers and peripherals (e.g. printers) within a limited area, often a classroom or building. *Wide area networks (WANs)* connect computers over greater distances, such as building to building, city to city, and so on. Overall, 75 percent of public schools have computers with some networking capabilities—either LAN or WAN access—and of those schools, 40 percent report that machines with these capabilities are located in classrooms;[1] 71 percent say they are located in administra-

[1] Many schools responding to the survey reported access in more than one location. U.S. Department of Education, *Advanced Telecommunications in U.S. Public Schools, K-12* (Washington, DC: U.S. Department of Education, OERI, February 1995), NCES 95-731

(continued)

BOX 1-3 (cont'd.) Technologies in U S Schools: Definitions and Availability

tive offices; 62 percent, in library/media centers; and only 15 percent in teacher workrooms. Electronic mail (e-mail) is the most common use of telecommunications reported by teachers who are accomplished telecommunications users.[2]

The Internet

The *Internet* is an international collection of interconnected electronic networks and a set of protocols for communication between computers on these networks. The protocols also include a large and growing list of services that can be provided or accessed over the Internet.

Of the schools reporting networking capabilities, 49 percent have WANs 35 percent of those have access to the Internet, and 14 percent have access to other types of wide area networks, such as America Online, CompuServe, or Prodigy. Of those with Internet access, on average, only 3 percent of schools have access in instructional rooms (classrooms, library/media centers, computer labs). This means students and teachers typically do not have access to Internet services.

Television/Video

Nearly every school in the country has at least one television set for instructional use Video is the most common technology used for instruction in schools, from sources such as direct broadcast and cable television and satellite (distance learning) As of 1991, the typical school had seven television sets and six videocassette recorders, which teachers typically use to record and show students commercially broadcast educational programs While the use of more interactive video resources, such as camcorders, videodiscs, and CD-ROM is growing, these are not used with as much frequency in schools.

Broadcast television (national networks, such as NBC, CBS, ABC) is received by 70 percent of all public schools (61 percent of schools receive PBS). Eighty-three percent of those schools report that broadcast access is available in classrooms, and 84 percent report access in the library/media center.

Cable television (subscription television, such as CNN, the Discovery Channel, The Learning Channel) is available in 74 percent of all public schools, and 70 percent of those schools say access is available in classrooms, while 85 percent report access in library/media centers

Closed-circuit television (neither broadcast nor cable, but in-house transmission on noncommercial lines) is only available in 25 percent of schools, but 94 percent of those schools say classrooms have access, and 89 percent report access to closed circuit TV in library/media centers

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[2] Margaret Honey and Andres Henriquez, *Telecommunications and K-12 Educators Findings From A National Survey* (New York Center for Technology in Education, Bank Street College of Education, 1993).

SOURCE Office of Technology Assessment, 1995, based on Henry J. Becker, "Analysis and Trends in School Use of New Technologies," Office of Technology contractor report, March 1994; also, *Advanced Telecommunications in U S Public Schools, K-12*, National Center for Education Statistics NCES 95-731 (Washington, DC. U S Department of Education, OERI, February 1995), see also chapter 3 of this report

ing and motivation, address students with different learning styles or special needs, expose students to a wider world of information and experts, and implement new teaching techniques. There are many examples of how technology has enhanced teaching:

- Students engaged in a group problem-solving project based on a software or video simulation are learning to work as a team, develop expertise in specific areas, become more confident learners, and weigh the merits of several possible solutions.

- Teachers involved in an international telecommunications project find their students acquiring a new interest in geography, and bonding with students across the globe or in the different world that exists even on the other side of town.
- With graphing software, students appear to develop a deeper understanding of mathematical concepts for which they had learned the formulas but had not applied consistently.
- Special education students, mainstreamed into regular classrooms, work on a more equal basis with their classmates when a computer speaks for them, gives them big print, or adjusts to their difficulties.
- Students who were on the verge of dropping out take a new interest in school when, as part of a class project, they interview other students with camcorders and create daily news shows.
- Using CD-ROM, students research a multimedia term paper, evaluating resources from print, video, and audio media.
- After the teacher downloads satellite pictures of daily weather patterns, students use a network to compare their weather data with weather data reported by students around the country, analyzing trends and predicting likely conditions.
- A scientist working on cancer research can come online and advise a student setting up a science project on molecular biology.

These kinds of experiences, while far from the norm in schools today, can and do occur in classrooms with access to technology and a teacher who can skillfully guide its use. In most of the above examples, teachers find that their students are doing more than learning generic technology skills or subject-specific technology applications. Rather, they see them developing the kinds of skills and competencies that numerous reform panels have encouraged as essential for all high school graduates—problem-solving skills; broader scientific literacy and mathematical understanding; strong communication skills; personal responsibility, integrity, and initiative; and skills and competencies for the workplace. These workplace competencies include working with resources, acquiring and evaluating information, working with others in groups or teams, understanding complex relationships and systems, and using a range of changing technologies.[9] Although these skills can be developed without technology, technological tools can help teachers structure, organize, or enhance the activities that facilitate the development of these skills.

APPLE CLASSROOM OF TOMORROW (ACOT)

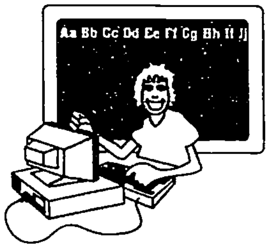
Teachers find that using technology can encourage students to take more responsibility for their learning, to learn to work cooperatively, and gain experience in acquiring, evaluating, and using information in various forms

Accomplished technology-using teachers indicate that using computers has changed their teach-

[9] See, e.g., Secretary's Commission on Achieving Necessary Skills, op. cit., footnote 4, Anthony Patrick Carnevale, *America and the New Economy* (Washington, DC: American Society for Training and Development, 1991), and William B. Johnston and Arnold H. Packer, *Workforce 2000* (Indianapolis, IN: Hudson Institute, June 1987).

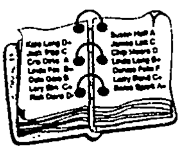
TABLE 1-1 Teaching and Technology: The Potential

Changing teaching and learning



- *Resources for teaching* abstract concepts, complex systems, problem solving—and basic skills
- *Resources for group work and collaborative inquiry*
- *Adaptable* to various student learning styles and special needs
- *Teachers report they:*
  —Expect more of students
  —Are more comfortable with students working independently
  —Present more complex materials
  —Tailor instruction more to individual needs
  —Adopt new roles, more "guide on the side" than "sage on the stage"
  —Spend less time lecturing, so classrooms are more student-centered

Assisting with daily tasks

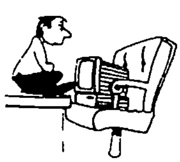


- *Preparing lesson plans*
  Online databases, CD-ROMs, videodiscs, and other electronic sources help teachers create, customize, and update lessons
- *Tracking student progress*
  Gradebook programs and databases to update student profiles and maintain records.
- *Communicating*
  Telephone, voice mail, e-mail to contact parents, other teachers, or administrators to plan meetings, discuss student and administrative concerns.

Enhancing professional development

- *"Just-in-time" training and support*
  Satellite, video, cable, or computer access to new ideas, master teachers, and other experts for training and followup
- *Formal courses and advanced degrees*
  Distance learning technologies for courses not available locally
- *Informal educational opportunities*
  Online contact with teacner colleagues and other experts.

Preparing new teachers



- *Models of effective teaching*
  Video can take prospective teachers into classrooms to watch effective teachers in action
- *Computer and video simulations and case studies*
  Give prospective teachers practice solving teaching challenges in a non-threatening environment
- *Electronic networks*
  Minimize isolation during field experiences, provide support and interaction with college faculty or mentors

SOURCE Office of Technology Assessment, 1995

ing.[10] Among the changes teachers reported were that they expected more of students, became more comfortable with students working independently, presented more complex material, tailored instruction more to individual needs, and spent less time lecturing and more time overseeing small groups or working one-on-one with students (see chapter 2, box 2-1). Some teachers suggest that using technology has meant they are transforming the educational process—their curriculum and classroom organization. These teachers report that, ultimately, they see a change in their roles as they become more like coaches, encouraging, guiding, and facilitating student learning, and students assume more initiative and responsibility for their own learning. While not all teachers want to make this transition from "sage on the stage to guide on the side," many find it exhilarating.

Assisting with Daily Tasks of Teaching

Teachers perform a wide variety of duties in addition to being instructional leaders, including preparing lesson plans and instructional materials, keeping and transmitting records of student progress, attending school meetings, meeting with parents, and staying abreast of the profession. Yet schools rarely consider the role of technology in assisting teachers with the many parts of the job that go on when the students are not present. And few schools have contemplated how teachers could use their time differently or how teaching personnel could be assigned more flexibly (e.g., teachers working with small groups of students for some parts of the day, large groups at other points) if teachers were freed from mundane tasks that technology could handle.[11]

Technology can assist teachers with daily activities in many ways:

- With electronic gradebook software, teachers can keep and more easily update running grading histories and profiles for every student and counsel them about problems as soon as they occur.
- Teachers can videotape student presentations to evaluate and maintain records of student performance as a part of assessment activities.
- By accessing an electronic database, a teacher can quickly locate a host of current materials relevant to next week's science lesson.
- A teacher can retrieve a voice mail message, at a convenient time, about a change in the time of a parent conference.
- Teachers can plan meetings with other teachers online and save time in coordinating multiple schedules.

OTA has observed that, as teachers develop expertise in these administrative applications, confidence grows, encouraging them to try additional applications to meet instructional and professional development goals.

Enhancing Professional Development for Today's Teachers

Teachers are learners too. They take courses, workshops, and other forms of training to fulfill recertification requirements, learn new instructional methods, or keep up with changes in their specialties. However, the current approach—typically a short inservice course on a specific topic in which a large group of teachers are gathered in one place for an "injection" of training—is limited and often disliked by teachers, administrators, and parents alike. For example, a school district may gather elementary school teachers from across the district to spend a morning learning about a new strategy for teaching reading. This "one-size-fits-all" model of training is rarely used in other pro-

[10] Karen Sheingold and Martha Hadley, *Accomplished Teachers: Integrating Computers into Classroom Practice* (New York, NY: Center for Technology in Education, Bank Street College of Education, September 1990).

[11] See, e.g., Margaret Riel, "The Future of Teaching," contractor report prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, Jan 12, 1994

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BOX 1-4 What Difference Does Educational Technology Make?

When a technology is introduced in education, many people want to compare its effectiveness with that of existing methods of instruction. In the 1960s and 1970s, a number of studies compared learning via radio and television with learning via classroom lectures or textbooks. More recently, many studies have been conducted comparing computer-assisted instruction with more traditional methods of instruction. These studies have consistently demonstrated that computer-assisted instruction technologies are either equivalent or superior to conventional instruction.[1] Meta-analyses, which examine the results of many studies and aggregate their combined effects, show effects that range from .26 to .66 standard deviations, which represent a sizable improvement on many achievement measures as well as positive attitudinal effects.[2] Small, but growing, numbers of studies have begun to examine effects of newer technologies such as videodisc or telecommunications networks.

Several factors belie simplistic approaches to the important but complex question of effectiveness. These issues include:

- *Conceptual factors*—are researchers, parents, teachers, and policymakers asking the right questions and interpreting available research correctly?
- *Methodological factors*—is the research designed well enough to answer questions of effectiveness? and
- *Timeliness factors*—with rapid advances in technology, including rapid obsolescence of yesterday's "new" technologies, do the research results tell interested parties what they need to know today to plan tomorrow's classroom uses of technologies?

Conceptual issues. In general, many available studies of the effectiveness of educational technologies can be thought of as "horse race" studies because, when interpreted too simplistically, they are expected to provide evidence that one technology can "beat" another by showing that students "learn more" when it is used.[3] This approach can be misleading.[4] Whenever a new educational treatment is tried its effects are not just attributable to the technology (e.g., computer, video, books) but also to the particular content (e.g., subject matter, targeted skills) and pedagogical approach(e.g., software, teaching materials, teachers, and classroom environment). The type of learner (e.g., age, previous achievement, special needs) also influences the effects of these other variables on learning. In other words, it is not the effects of the technology by itself that are analyzed in these studies, but the aggregated effects of *how the technology is being used in the classroom context*. Available and future research should be interpreted with an eye to these factors, which can attenuate or enhance the effects of particular technologies.

[1] See, e.g., C Kulik and J.A. Kulik, "Effectiveness of Computer-Based Instruction An Updated Analysis," *Computers in Human Behavior*, vol 7, pp 75-94; John Pisapia and Stephen M Perlman, "Learning Technologies in the Classroom: A Study of Results" (Richmond, VA. Metropolitan Educational Research Consortium, Dec 1992); Alice Ryan, "Meta-analysis of Achievement Effects of Microcomputer Applications in Elementary Schools," *Educational Administration Quarterly*, vol 27, No. 2, May 1991, pp 161-184; Interactive Educational Systems Design, Inc., *Report on the Effectiveness of Technology in Schools, 1990-1994* (Washington, DC. Software Publishers Association, n d.).

[2] Mark W Lipsey and David B Wilson, "The Efficacy of Psychological, Educational, and Behavioral Treatment Confirmation from Meta-analysis," *American Psychologist*, December 1993, Effect size (ES) is a measure of the difference between a control group that did not use the technology and the treatment group that did. ES is expressed in standard deviation units "An ES of 17 is quite small and unimportant, whereas an ES of 33 is modest but important To interpret the numbers more easily, they can be converted to percentiles For example, an effect size of 33 means that the treatment group would be at the 63rd percentile compared with the control group at the 50th percentile " (J Johnston, *Electronic Learning*, 1987, p 50.)

[3] Barbara Means et al., *Using Technology to Support Education Reform* (Washington, DC U S Government Printing Office, September 1993), p 73

[4] Means et al, op cit, footnote 3, Ann D Thompson, Michael R Simonson, and Constance P Hargrave, *Educational Technology: A Review of the Research* (Washington, DC Association for Educational Communications and Technology, 1992)

BOX 1-4 (cont'd.) What Difference Does Educational Technology Make?

Methodological Issues. It is important to note that there are several basic factors frustrating researchers, teachers, and policymakers looking for simple yes or no answers about technology's effectiveness One is the overall context of real world educational research. As one researcher noted, "Schools are messy and noisy environments for research, far from the pristine, controlled setting available in the research laboratory, the model on which most quantitative evaluation studies are based."[5] Comparable comparison groups are scarce, interventions with technology are usually a part of broader interventions that also influence outcomes; and different treatments for experimental and control groups run counter to a teacher's impulse to treat all students equitably.

A second major flaw in the existing research is the lack of good outcome measures for assessing the impact of technology-based innovations. Most of the research to date relies on existing measures of student achievement (e.g., standardized achievement tests). Although there are many promising efforts to broaden the kinds of indicators that can be used to assess student achievement, these are not yet in widespread use.[6] New achievement measures would assess areas that many believe can be particularly affected by using new technologies (e.g., higher-order thinking) Also key, however, is the need to include outcomes that go beyond student achievement, because student achievement may be affected by students' attitudes about themselves, school, and learning, and by the types of interactions that go on in schools. For example, some research has documented the positive effects of computer-assisted instruction on students attitudes about school and learning.[7] Also promising is recent research that suggests that technology-based innovations can affect student self-concept as well as interactions between students and teachers in the classroom environment.[8] Technological changes are likely to be nonlinear, and technological changes may show their impacts not only on student learning, but also on the curricula, the nature of instruction,[9] the culture of schools, and the fundamental ways teachers do their jobs.

Timeliness. The rapid pace and the potentially high cost of some technological changes[10] create a dilemma for the typically slower pace of careful research. Policymakers—and taxpayers—faced with deciding whether to invest millions of dollars in an information infrastructure typically want to know whether their investment will be worth the increased financial burden (assuming technology does not replace existing methods) For example, they will want to know whether what is on the "information superhighway" will really help their children achieve, whether putting a telephone on every teacher's desk will really improve parent-teacher communication, or whether investing in new personnel to provide "just-in-time" support for technology-using teachers will enhance the instructional capabilities of existing technology investments Equally reasonable seem the frustrations of those who have experienced the promise of particular educational technologies in small experimental programs (e.g., downloading real-time information on weather data from satellites for science lessons). By the time the external evidence has been compiled, "proving" that technology integration works and districts are ready to commit to purchases of the appropriate hardware and software, the technology that has been researched may be obsolete and a golden opportunity to use it for current students will have been lost.

[5] Joan O Herman, "Evaluating the Effects of Technology in School Reform" *Technology and Education Ref . The Reality Behind the Promise*, Barbara Means (ed) (San Francisco, CA Jossey-Bass Publishers 1994) p 145

[6] See *Testing in American Schools Asking the Right Questions*, OTA-SET-519 (Washington DC U S Government Printing Office, February 1992)

[7] Thompson et al , op. cit , footnote 4

[8] J Sivin-Kachala and Ellen R Bialo, *Report on the Effectiveness of Technology in Schools 1990-1994* (Washington, DC Software Publishers Association, n d)

[9] Jerome Johnston, *Electronic Learning From Audiotape to Videodisc* (Hillsdale, NJ Lawrence Erlbaum, 1987)

[10] The costs of educational technologies are not known with certainty What is known is that they will vary considerably depending on an array of factors See section on "Costs" later in this chapter

(continued)

BOX 1-4 (cont'd.) What Difference Does Educational Technology Make?

Directions for the Future. Although there are some promising studies, more research on the broad variety of educational effects of technology is needed. A more fruitful research approach than merely asking whether a particular technology works is to ask about the "value added" to instruction when technology is present in schools; in other words, when, why, and how do technologies improve teaching, professional development, and, ultimately, learning for children? Increasingly, researchers are concentrating their efforts on this type of more contextualized research—studying how complex-technology-based innovations "work" in real classroom settings over time. Such research can help to determine how technology environments can best be designed to support student learning and what approaches to instruction work best in conjunction with various types of technologies for what kinds of subject matter. The role of the teacher in implementing and facilitating student learning in such environments is an important focus of such studies.[11] Additional research models are needed to deepen understanding about which instructional uses of technology are most effective and under what circumstances, and how teacher interactions with technology play into this effectiveness. By taking a more contextualized approach, research can help schools, parents, teachers, and policymakers understand the necessary steps to diffusing and continuously refining educational technologies in the schools.

[11] For examples of this kind of research see A.L. Brown, "Design Experiments: Theoretical and Methodological Challenges in Creating Complex Interventions in Classroom Settings," *Journal of the Learning Sciences*, vol. 2, No. 2, pp. 141-178; Cognition and Technology Group at Vanderbilt, "The Jasper Experiment: An Exploration of Issues in Learning and Instructional Design," *Educational Technology Research and Development*, vol. 40, pp. 65-80, 1992.

SOURCE: Office of Technology Assessment, 1995.

fessions, and, although it may be efficient for school districts, many suggest it is not the most effective way to encourage teachers to learn new skills or teaching approaches. It appears to be a particularly ill-chosen method for encouraging teachers to use technology, where hands-on training with the hardware and software, curriculum-specific applications, and followup support are all necessary.

OTA has found examples of how technology can provide teachers with "just-in-time training and support" when and where they need assistance in many curricular areas. It can transcend the walls of isolation that separate teachers and extend formal and informal learning opportunities. The following are some examples:

- Without leaving their school buildings, teachers from across the 90 school districts in sprawling Los Angeles County can participate in a satellite staff development course on topics such as how to apply the California history and social science framework in lessons in their classrooms.
- School counselors from across Wyoming meet regularly over a compressed video network to discuss student truancy and behavior problems.
- A special education professor at the University of Northern Iowa offers courses to teachers throughout the state over the Iowa Communication Network. With this fiberoptic network, teachers at each site can see and hear each other as they develop skills for add the certification credits that will enable them to teach students with moderate, severe, and profound mental disabilities.
- Mathematics teachers use a computer network to discuss the mathematics teaching techniques they have observed through video presentations in the Mathline project sponsored by the Public Broadcasting System.

- Using cable television, teachers from remote locations around the country can take courses leading to a masters in educational technology degree from George Washington University in Washington, DC.

In examples like these, technology can be the vehicle for providing teachers access to new ideas, master teachers and other professionals beyond their school setting, in both formal and informal courses and enrichment activities. It can also provide the support teachers need after a course ends, as they apply and refine in the classroom the lessons and techniques they have learned.

Preparing New Teachers with Technology

In colleges of education where technology is an integral part of the teacher education preservice program, technology has been used not just to train prospective teachers about technology, but also as a resource to enhance the overall teacher preparation experience. For example, live broadcasts, tapes, video networks, CD-ROMs or videodiscs can provide teacher education students with case studies or models of effective teaching. Furthermore, technology—whether computer or video networks—can create closer connections among student teachers, college of education faculty, and mentor teachers in K-12 classrooms, whether in lab schools or professional development schools closely allied with colleges of education, or in more traditional student placement activities. Electronic networks can provide a safety net for communication, sharing knowledge, and experience for student teachers in the field, as well as for new teachers launching their careers. The loneliness and anxiety common to teachers' first teaching experiences can be mitigated through contact with professors and peers via electronic networks. The following are examples of ways technologies have enriched preservice teacher education:

- Teacher education students at the University of South Carolina appreciate what students with language learning disabilities might experience when dealing with text by working with a software simulation called "The Language Mangler." Another simulation serves as a surrogate field observation, enabling prospective teachers to observe, critique, and discuss ways teachers handle students with special needs in a variety of settings.

The use of technology in teacher preparation programs is limited but it can enhance the overall preservice experience

- At the Peabody College of Education at Vanderbilt University, teacher education students review CD-ROM discs that contain video cases of mathematics teachers working with students. Teacher education students can each have copies of the inexpensive CD-ROM discs, play them on computers supplied with CD-ROM drives in dorms and on campus, and review teaching techniques individually or in a group. They add notes and observations on accompanying software that serves as an electronic notebook, which instructors then collect electronically for grading and return.
- All the schools in which the University of Virginia's Curry School of Education preservice students spend their internships are linked to Virginia's Public Education Network, permitting the teaching intern, the supervising teach-

er, and the faculty at the Curry School to confer via the electronic network throughout the teaching internship.

- At the Price Lab School at the University of Northern Iowa, a fiberoptic network linking the college and the lab school enables teachers in any of the 48 classrooms at the lab school to ship video to teaching methods classes. Teacher education students see lessons related to topics they are discussing in their courses and, with two-way video and audio, talk to the teacher after they see the lesson and hear tne teacher's on-the-spot analysis of what worked and what was problematic in that lesson. Since most lab school faculty use technology in their classes, the teacher education students can see effective modeling of technology use via technology.
- University of Wyoming students conducting student teaching meet via a compressed video system with their supervising faculty member, collaborating teacher, and clinical supervisor as often as necessary to discuss problems and questions arising out of student teaching experiences.

TEACHERS AND TECHNOLOGY: THE BARRIERS

While promising, the above examples of what technology can do are far from the reality in many schools, in colleges of education, or in the daily teaching experience or professional development of the typical teacher. There are a number of common barriers to more widespread use of technology by teachers (see table 1-2):

- First, there is the question of access to appropriate technologies. The question of access is also tied to problems of costs.
- Although most teachers see the value of students learning about computers and other technologies, many teachers lack a clear understanding about what resources technology can offer *them* as they try to meet their instructional goals.
- As do most users of emerging technologies, many teachers encounter technical and logistical problems they cannot solve themselves and often lack the training and support necessary to resolve the problems.
- Many feel the need for more knowledge—not just about how to run the machines—but about what software to use, how to integrate it into the curriculum, and how to organize classroom activities using technology.
- The current assessment system, if it relies heavily on standardized achievement tests, can also be a barrier to experimentation with new technologies because teachers are not sure whether the results they are seeking will be reflected in improved student test scores.
- In addition, issues created by technology itself are also factors to be dealt with, including those related to copyright and intellectual property rights, privacy of student records, and control of student access to objectionable materials.

Access Issues

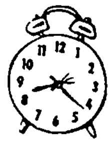
Equipment

One basic prerequisite for effective teacher use of technology is access. Schools have made substantial investments in hardware and software over the past several years, increasing their technology inventories (see box 1-3). OTA finds that, despite past investments in technology, many schools still lack the basic technology infrastructure to support the most promising applications of educational technology. About half the computers in U.S. schools are older, 8-bit machines that cannot support CD-ROM-sized databases or network integrated systems or run complex software. This aging inventory limits the ability of many teachers to use some of the most exciting applications of computers—information gathering from networked databases or CD-ROM encyclopedias, desktop publishing, mathematics instruction using analytic graphing and calculating software, and collaborating in joint projects over networks.

Some schools do not always make the most of the equipment they already have, and some do not

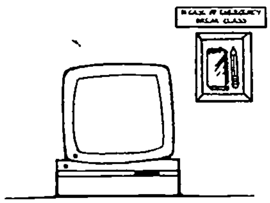
TABLE 1-2: Teaching and Technology: Current Barriers

Teacher time



Teachers need time to:
- Experiment with new technologies.
- Share experiences with other teachers
- Plan and debug lessons using new methods that incorporate technologies.
- Attend workshops or training sessions

Access and costs



In addition to limited hardware and software, other factors affect access
- Costs are high for purchasing, connecting, and training to use technologies
- Technologies may not be located in or near the classroom
- Hardware in schools today is old (50 percent of computers in schools are 8-bit machines) and cannot handle many newer applications
- New or additional wiring or phone lines are necessary for telecommunications networks

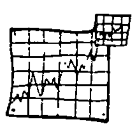
Vision or rationale for technology use

- Schools must have plans. and teachers a clear understanding of curricular uses of technology
- It is difficult to keep up with the rapid rate of technology development and changing messages of best use
- Teachers lack models showing the value of technology for their own professional use

Training and support

- Overall, districts spend less than 15 percent of their technology budgets on training. but they spend 55 percent of the budget on hardware and 30 percent on software.
- Technology training today focuses primarily on the mechanics of operating equipment. not on integrating technology into the curriculum or selecting appropriate software
- Only 6 percent of elementary and 3 percent of secondary schools have a full-time, school-level computer coordinator for technical support

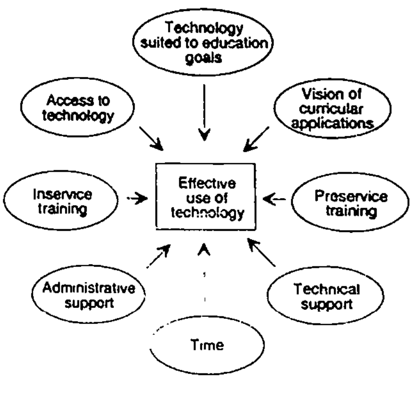
Current assessment practices



- Existing standardized measurements of student achievement may not reflect what has been learned with technology
- Teachers are held immediately accountable for changes that take time to show results

SOURCE Office of Technology Assessment, 1995

FIGURE 1-1: Requirements for Effective Use of Technology



SOURCE: Office of Technology Assessment, adapted from Jane L. David "Realizing the Promise of Technology: Policy Perspective" in Barbara Means (ed.), *Technology and Education Reform* (San Francisco: Jossey-Bass Publishers, Inc., 1994) pp. 169-189

always locate technology in the most accessible places. Most computers are still in labs rather than in classrooms, and modems may be located on a central computer in the principal's office, making it hard for teachers to use them during the course of a day. Thus, it is not surprising that computers are not used very often (about two hours per student per week, according to coordinators; less, according to the students). They are not used regularly in the teaching of academic subjects—only 9 percent of secondary school students reported using computers for English class, 6 to 7 percent for a math class, and 3 percent for a social studies class. The most common uses of computers are for basic skill practice at the elementary level and word processing and other computer-specific skills in middle and high schools. Other uses, such as desktop publishing, developing math or science reasoning with computer simulations, gathering information from databases, or communicating by electronic mail (e-mail) are much rarer. And, despite the growing interest in connecting schools with information resources like the Internet, most school districts with local area networks do not always configure them or use them for the most up-to-date applications.

Furthermore, a majority of schools are ill-equipped to take advantage of the potential presented by telecommunications networks. Fewer than one teacher in eight has a telephone in the classroom that can be used for outside calls. Moreover, most schools lack the connectivity, administrative and organizational support, and technical expertise needed to integrate networks into teaching and learning.

OTA finds that it is necessary to consider a new definition of what constitutes "access" to technology by teachers and students. Counts of equipment, student-computer ratios, dollars spent and requirements, while important, alone are not sufficient to define meaningful access to technologies. It is appropriate rather to consider infrastructure in a broader sense: type of technology (including older but overlooked resources such as the telephone), age, capacity, connectivity, software, and services. Organizational arrangements—the placement and flexibility of technology—also affect the ease of use by teachers and students. For example, a cart of laptop computers that can be moved anywhere in a school may be used much more often than a computer lab far from the classroom. An additional component of a new definition of access includes the kinds of support teachers need to use the infrastructure effectively: exposure to innovative uses, flexible "just-in-time" training, and ongoing technical support and expert advice.

If access to technology is an equity concern, then the definition should be expanded to encompass access to necessary information. Telecommunications and networking technologies, in particular, may create incomparable opportunities for teachers and students to gain immediate access to information. Combined with hardware like CD-ROM players, the excitement and power of video can be combined with the information transmission power of the computer and communication

capabilities of high speed networks. Connectivity is likely to become the major technology issue of the next several years. Major investments of time and other resources will be required to prepare schools to effectively access the information and electronic communities telecommunications can provide.

Costs

As new technologies, new opportunities for increased levels of connectivity, and educational applications emerge, those concerned with expanding the use of technology in schools and by teachers have turned their attention to the issue of cost.[12] The cost of any new initiative is always an issue for elementary and secondary education, which is funded almost exclusively by a combination of state and local taxpayers. Some have suggested, however, that there be greater roles for the federal government, private businesses, or some combination to ensure that schools obtain new technologies. These suggestions have stimulated the Congress to direct the U.S. Department of Education (ED) to estimate costs on a national basis.[13] The ED estimate, to be developed by the Rand Corporation under contract to ED, was not available at the time this report was prepared. Previous attempts at rough estimates, at the state and national levels, can be informative in illustrating the range of costs—and the range of uncertainty—involved.

States vary greatly in their installed base of technology, their technology plans and goals, and the numbers of students served (see chapter 3, figure 3-5). Consequently, states will require varying levels of funding to meet these goals. For all states, however, substantial commitments will be required.

The costs of technology are a major hurdle for many schools

Table 1-3 estimates installation and operating costs of selected telecommunications technologies. The table is based on rough estimates by OTA of the costs of installing telephone lines in all U.S. classrooms, and by projections made by two economists[14] based on various configurations for connecting schools, school districts, and/or classrooms. Analysis of the estimates suggests that *at the national level* and *depending on a variety of factors*:

- estimated one-time installation costs (including training) *may range* from $0.08 billion (for one personal computer plus modem per school, connected to the Internet through a school-district-based file server) to $145 billion (to have one personal computer per student desktop, with full, ubiquitous connection to the Internet for a complete suite of text, audio, graphical and video applications); plus
- estimated annual operating costs for the configurations described above (including annual

[12] See, e.g., Russell I. Rothstein, "Connecting K-12 Schools to the NII. A Preliminary Assessment of Technology Models and Their Associated Costs," a working paper (Washington, DC: U.S Department of Education, Aug. 4, 1994). Robert Cohen, "The Cost of NII Access to K-12 Schools: Preliminary Assessments," paper provided by Robert Blau, director, Policy Analysis, Bell South, Washington, DC, 1994.

[13] See, e.g., Public Law 103-382, Title III.

[14] Rothstein and Cohen, op. cit., footnote 12

TABLE 1-3: Estimated Installation and Operating Costs of Selected Telecommunications Technologies

Examples of technology, training, support, and infrastructure configurations	Source of estimate	Range of estimated one-time installation and training costs	Range of estimated annual operating costs	Limits on capability
Telephone in each public school classroom	OTA[a]	$123.00 mil [b] (low) - $220.00 mil (high)[c]	$310.00 mil (low)[d] - $333.00 mil (high)[e]	Phone line could be used to connect to modem.
One personal computer (PC) plus modem per school, connected to a school-district-based file server, connected to the Internet, with minimal initial teacher training, and $2-$10K per year for teacher support and $1-$5K per year for teacher training.	Rothstein, 1994	$80.00 mil. (low) - $390.00 mil (high)	$160.00 mil (low) - $560.00 mil (high)	Limited access by teachers and students, allows text-based applications only (e.g., e-mail, telnet, gopher)
An average of 60-100 PCs, modems, and a local area network (LAN) using copper wire per school, district-based file server to remote locations, LAN, router to the Internet; initial teacher training of 5 to 20 staff per school, and annual teacher support and training	Rothstein, 1994	$2.59 bil (low)- $7.75 bil (high)	$1.37 bil (low)- $3.38 bil (high)	Supports only a few users at a time because it is limited by the number of phone lines going out of the school
One PC per classroom with additional dialup lines Districts support file server to remote locations, LAN, and router to the Internet, with initial teacher training of 10-20 staff per school and annual teacher support and training of 1-2 support staff per district, and $10-20K for training. Includes major retrofitting costs	Rothstein, 1994, Cohen, 1994	$5.38 bil (low)- $13.26 bil (high)	$1.30 bil (low)- $3.84 bil (high)	No real-time access to video or graphics

60 PCs per school plus LAN, file server with high-speed links, and router. District offices have LAN, file server to remote locations, and router, with initial teacher training for 40-50 staff per school and annual teacher support and training of 3 support staff per district, plus annual training costs of $15-$35K	Rothstein 1994	$11.75 bil (low) - $27.53 bil (high)	$1.85 bil (low) - $4.94 bil (high)	Base needed for connecting each public school to the Internet, allowing use of "limited" video, graphical and text-based network applications
1 PC per desktop, plus school-based LAN, a larger file-server, and router to district office, each district has a file server to remote locations, LAN, a high-speed line to school, and a larger dialup system than in previous model, with initial teacher training for all teachers in all schools, and annual teacher support and training consisting of 4-5 support staff per district, plus annual training costs of $16.5-$38.5K. Includes significant retrofitting costs.	Rothstein 1994	$65.80 bil (low) - $145.62 bil (high)	$4.46 bil - $11.28 bil	Full connection to the Internet, supports full suite of text, audio, graphic and video applications. Would not support full-motion video
4 schools per district have PCs, LAN, file server/router, each district has a file server LAN, a data line to wide area networks, and dialup lines, assumes initial training costs of $100K and annual support and training costs of $133K total. Includes costs of retrofitting school buildings	Cohen 1994	$35.76 bil	$5.49 bil	None. Individual schools linked directly to a national information infrastructure; circuit can accommodate very wide array of services including full motion video

[a] Figures do not reflect the fact that one-eighth of classrooms now have phones, thus these estimates may be too high

[b] Based on an estimate of 83,389 public schools (Software Publishers Association 1994) with an average of 20 classrooms per school (Rothstein 1994)

[c] Includes additional charges for labor and installation (optional) of $42 upfront charge plus $16 for 15 minutes (per classroom) for an additional cost of $96,731,240

[d] Calculated for regular (non centrex) service as follows: $16.77 per line monthly charge + $1.45 per month message unit charge (@ 20 message units per month) = $18.22 X 10 months in school year X 1,668,000 classrooms = $303,909,600. Figures may not total exactly due to rounding

[e] Calculated for centrex service as follows: $18.22 per line monthly charge + $1.45 per month message unit charge (@ 20 message units per month) = $19.95 X 10 months in school year X 1,668,000 classrooms = $332,766,000 $291,170,250. Figures may not total due to rounding

SOURCE: Office of Technology Assessment 1995, based on Russell I. Rothstein, "Connecting K-12 Schools to the NII: A Preliminary Assessment of Technology Models and Their Associated Costs," a working paper (Washington, DC: U.S. Department of Education, Aug. 4, 1994); Robert Cohen, "The Cost of NII Access to K-12 Schools: Preliminary Assessments," paper provided by Robert Blau, director, Policy Analysis, Bell South, Washington, DC, 1994


ANDREW M. LEVINE

Teachers working together can create a shared vision for technology use

training and support for teachers) *may range* from $0.16 billion to $11.28 billion.

The range in the estimates in table 1-3 is striking, and the estimates could easily be far from the mark. Furthermore, these estimates have not considered costs of using additional technological configurations that offer potential, such as cellular telephones and wireless modems.[15]

Key factors that appear to account for current differences in available estimates include:

- the configuration of technologies envisioned for the estimate (from a simple telephone line, to technologies that are on the cutting edge);
- the number of desktops, classrooms, school buildings, and school districts that are assumed to obtain access to the system;
- the amount of retrofitting required of school buildings (e.g., to install new wiring for telephone and cable lines or to provide additional electrical power, to deal with asbestos during required construction); and
- the amount of support and training required for the human resources—the teachers—to make best use of the new technologies.

Clearly, different assumptions about these factors—and development of new, perhaps less expensive, technologies in the future—could greatly affect cost projections. In addition, at the local level, prices for individual technologies may vary considerably, meaning that any one school, school district, or state could experience a considerably different level of costs than any other.[16]

A Vision of Goals and Rationale for Technology Use

There is also a gap between having technology and using it effectively. As described above, equipment is often placed in locations where it is inconvenient for regular classroom use. Furthermore, schools and teachers have received conflicting advice over the years about the best ways to use their technology. As the technology has evolved, so has the prevailing wisdom on how teachers should use technologies in schools—from teaching programming, to encouraging individualized drill and practice, to building computer literacy, to participating in electronic communities. Conventional thinking also has shifted about how to organize technology resources, from self-contained labs, to one computer per classroom for teacher demonstrations or single student tutorials, to a few computers per classroom on which stu-

[15] See U.S. Congress, Office of Technology Assessment, study on wireless telecommunications, forthcoming.

[16] The policy issues and options section of this chapter provides examples of how different state policies (e.g., with respect to group purchasing, with respect to subsidies for telecommunications charges) can affect the costs actually incurred at the local level.

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dents can work in small groups, to one computer per student and on the teacher's desktop. It is small wonder that teachers have become confused, and administrators frustrated, with many educators unclear where they should be headed in directing technology use.

Support and Training

Other barriers in many schools hamper more effective use of technology by teachers. These include lack of time, inconvenient scheduling, attitudinal barriers, and barriers of school organization, curriculum, testing, and other policies.

In general, teachers have little in the way of technology support or training available at their schools, although many teachers seek training on their own. Currently schools spend much more on hardware (55 percent) and software (30 percent) than they do on training (15 percent). Less than half of American schools report that an introductory computer course is available for teachers through the district or a local college.

Furthermore, the kind of training, not just availability, is important. Much of today's educational technology training tends to focus on the mechanics of operating new machinery, with little about integrating technology into specific subjects, how to choose software, and how to organize classes, e.g., to use four computer workstations or a single computer with a modem.

Regular, onsite support for technology use is an even more daunting problem. Only 6 percent of elementary and 3 percent of secondary schools have full-time school-level computer coordinators; in nearly three-fifths of schools, no one had any portion of their workweek officially allocated to coordinating computer activities. Even in schools where someone is designated to spend at least half of his or her time as computer coordinator, very little of this time goes directly to training or helping teachers use computers.

Probably the greatest barrier to technology use, however, is simply lack of teacher time—time to attend training or workshops, to experiment with machines and explore software, to talk to others teachers about what works and what doesn't, and to plan lessons using new materials or methods. The diverse jobs teachers are asked to do and roles they are asked to play also affect their ability to take on another challenge. Teachers are given very little compensated staff development time and there are multiple competing demands for this time. Unless there are significant changes to the rhythm of the school day or changed incentives for giving teachers more time to learn and experiment with new technologies, this barrier to technology use will remain immense.

Other Emerging Issues

As the possibilities for widespread information networks—and their use by schools, teachers, and students—emerge, other issues are coming to light that may affect the ability of teachers to use technologies for administrative, instructional, and professional development purposes. These issues include copyright and intellectual property issues, privacy of student records, and censorship of objectionable materials versus protecting students' access to potentially valuable information.

Copyright and Intellectual Property Issues

Currently, one of the most widespread and promising uses of telecommunications technology by teachers is the retrieval of information from remote sources, including networked information, collections of books, journals, music, images, databases, software, and multimedia works—so-called digital libraries.[17] As students and teachers develop multimedia materials or projects, share them with colleagues, and store them in portfolios for student and teacher evaluation, use of copyrighted works in the classroom could grow dra-

[17] Margaret Honey and Andrés Henriquez, *Telecommunication and K-12 Educators: Findings from a National Survey* (New York, NY: Center for Technology in Education, Bank Street College of Education, 1993).

matically. Some examples of student use of such materials might include:[18]

- creating a Quicktime clip from a segment of a videodisc of a popular movie,
- digitizing a video clip from a "60 Minutes" segment,
- scanning a copyrighted photograph to use in a HyperStudio program,
- using music from a compact disc for background, and
- scanning a copyrighted picture of "Goofy" to use in a project.

Teachers' use of new media and curriculum development activities using copyright materials might include such activities as:

- keeping student developed multimedia projects using materials cited above as examples to show others,
- showing multimedia projects at professional conferences,
- sharing multimedia projects over the school district's cable channel,
- using an object from a copyrighted authoring program in another courseware authoring program for teaching purposes, and
- sharing projects on a listserv on the Internet.

These applications all raise issues related to fair use of copyright material and copyright protection.

The nature of digital works also changes how people read or use the works,[19] which presents new challenges to educators for the proper use of intellectual property. In earlier work,[20] OTA has found that the application of intellectual property law to protect works maintained in digital libraries continues to be uncertain; concepts such as "fair use" are not clearly defined as they apply to these works, and the means to monitor compliance with copyright law and to distribute royalties are not yet resolved. Resolution of these issues will provide teachers with clearer guidance for using digital information; meanwhile, school systems must struggle to remain in compliance with the existing law.

Privacy of Student Records

Use of computers by teachers may raise new issues of privacy for teachers and their students. One area of particular concern is computerization of student records. Increasingly, educators and policymakers will use data gathered and maintained in computers to monitor progress toward educational achievement standards, determine how well curricular content areas are covered, track performance of all students, and analyze information about special groups, such as disadvantaged and language-minority children.[21] In some states, lawsuits have challenged the right of state educational agencies to create computerized records by

[18] Rosemary Taub, College of Education, Kansas State University, personal communication, August 1994

[19] Digital information differs from information maintained in more traditional forms (e.g., analog) in several ways. 1) digital works are easily copied, with no loss of quality; 2) they can be transmitted easily to other users or be accessed by multiple users; 3) they can be manipulated and modified easily and changed beyond recognition; 4) they render text, video, and music to an essentially equivalent series of bits and store them in the same medium; 5) they are inaccessible to the user without hardware and software tools for retrieval, decoding, and navigation; and 6) with appropriate software, they create opportunities to experience works in new ways, for example, interactive media.

[20] U.S. Congress, Office of Technology Assessment, *Finding A Balance: Computer Software, Intellectual Property, and the Challenge of Technological Change*, OTA-TCT-527 (Washington, DC: U.S. Government Printing Office, May 1992).

[21] National Education Longitudinal Study of 1988, Student Questionnaire, prepared for the U.S. Department of Education, National Center for Education Statistics.

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collecting individually identifiable data. Typically the legality of such data collections is upheld, but not always.[22]

The Family Education Rights and Privacy Act of 1974 (FERPA), commonly called the "Buckley Amendment" after former New York Senator James Buckley, was enacted in part to safeguard parents' rights and to correct some improprieties in the collection and maintenance of public records. The legislation establishes the right of parents to inspect school records, limits access to school records (including test scores) to those who have legitimate educational needs for the information, and requires written parental consent for the release of identifiable data.

The growing use of computers to collect and store potentially sensitive information also requires heightened awareness from computer users about their responsibility to respect confidentiality when accessing data. It is already evident to users of electronic information technologies that functions such as e-mail make the anonymity and ease of manipulating data within electronic communities far more likely.

Censorship and Protecting Student Access to Information

A particularly challenging issue for K-12 education is finding the appropriate balance between encouraging students' rights of access to information and protecting students from objectionable materials and potentially harmful contacts over wide area networks. Bringing the world into the classroom is a laudable concept, but it can also have a downside. Educators and parents are concerned that children will be able to gain access to pornographic, dangerous, salacious, or otherwise undesirable material over networks, material that might never be allowed in textbooks, school libraries, or at home. The same information superhighway that makes it possible for students to talk to the Archbishop of Canterbury or the state governor online could also link them to criminals, pedophiles, or psychopaths.[23] As one news article recently noted:

> The cyberspace battles may prove especially contentious, because the Internet contains a great many works not found on the shelves of most schools. "The School Stopper's Textbook," for instance, tells how to short-circuit electrical wiring, set off explosives in school plumbing and "break into your school at night and burn it down." . . .Schools can keep a pornographic book off the library shelf by not buying it, but they can't keep it from entering the building through cyberspace.[24]

Some educators fear that, without proper safeguards, concerns like this could block the educational potential of telecommunications in schools. Schools are also worried about the potential for litigation, since some states prohibit "exposing minors to dangerous material or information."[25] Some schools have addressed this issue by educating teachers about the potential "risks" on the Internet: others have developed network use policies that students and parents must sign. For example, a school district in Colorado sends home a notice warning parents that potentially "defamatory, inaccurate, abusive, obscene, profane, sexually oriented, threatening, racially offensive, or illegal material" exists online.[26]

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22 Aaron M. Pallas, "Statewide Student Record Systems. Current Status and Future Trends," National Education Goals Panel, Mar. 26, 1992. Some teachers have also voiced concern that states will use the data for accountability purposes that teachers believe are inappropriate, thereby jeopardizing local autonomy While most states do not use their statewide student record systems for accountability purposes, local districts and state education departments may disagree about the propriety of these purposes

23 Paul Evan Peters, "In Your Face in Cyberspace," *Educom Review*, September October 1994, pp 70-73

24 Stephen Bates, "The Next Front in the Book Wars," *The New York Times*, Educational Life Section, Nov. 6, 1994, p 22.

25 Ibid

26 Ibid

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Other schools have given accounts and passwords to teachers only, not allowing students access to telecommunications. However, many educators consider this educationally shortsighted, especially since the possibilities of exploration and freedom of inquiry are what many find so promising about the Internet.[27] Increasingly, schools have put some of the responsibility on the students, setting up rules for permissible "surfing" (browsing through discussion groups or information sources) and taking away student passwords or accounts if they engage in "hacking" (destroying files or other materials on a computer system) or 'flaming" (using abusive or offensive language on e-mail). Still others seek technological solutions that block access to certain areas of the Internet: development is underway on "reverse firewalls" that keep users from going beyond prescribed areas on the Internet. Until such prototypes are in place, schools and teachers face a substantial challenge.

PROMISING APPROACHES TO TECHNOLOGY IMPLEMENTATION

> The challenge of integrating technology into schools and classrooms is much more human than it is technological. What's more, it is not fundamentally about helping people to operate machines. Rather, it is about helping people, primarily teachers, integrate these technologies into their teaching as tools of a profession that is being redefined through the . . . . process.[28]

Some schools and colleges of education are developing approaches to technology implementation from which others can benefit. The approaches differ, depending upon the existing resources (human and technological) at a site, the visions the sites have developed for how technologies are to be used and what problems they can address, and the leadership and support marshaled to meet those goals. These approaches include the following:

- developing technology-rich classrooms, schools, or districts, in which local expertise in various applications of technology can be developed and shared;
- training master teachers, who then serve as resources for their colleagues;
- providing expert resource people from other staff, such as librarians, computer coordinators, or volunteers from business, parent, and student groups;
- giving every teacher a computer, training, and time to develop personal confidence and expertise;
- training administrators so they can serve as technology supporters and guide efforts within their schools or jurisdiction; and
- establishing teacher or technology resource centers, ideally with ease of teacher access through online services.

Most schools combine several of these approaches, and there is no clear evidence that any one model is more successful than others. OTA found a number of promising practices, including the following examples:

- At Webster Elementary School in St. Augustine, Florida, all staff received broad training in technology use, but those interested were given more time, more training, and the opportunity to attend conferences. They became the "local experts" that other teachers could draw on for assistance or advice.
- To ease the burden of setting up alternative arrangements for substitutes, the Monterey California Model Technology Schools developed the concept of "SuperSubs," in which teachers on early retirement, armed with technology lessons and resources, substitute

[27] "Lifelong Learning and the NII," unpublished proceedings, Westfields Conference Center, Chantilly, VA., Nov. 18-20, 1994.

[28] Barbara Means et al., *Using Technology to Support Education Reform*, OR 93-3231 (Washington, DC: U.S. Department of Education, Office of Research, September 1993), pp. 83-84

for other teachers who are then free to observe still other teachers' technology lessons and approaches.

- In Indiana, four schools were given grants allowing every teacher to receive a computer and printer for use at home or in school, to improve their personal productivity and, ultimately, instructional efforts. Training, involvement of support staff and administrators as well as teachers, and broad public commitment helped to meet the goals of the program.
- In the Apple Classroom of Tomorrow Teacher Development Center Project, principals are encouraged to attend training with teacher teams and commit to providing extra time and resource for teachers to work together, reflect on what they are learning and doing, and assist their colleagues in technology activities.
- Texas supports 20 regional education service centers, with extra funding to support technology initiatives, including such areas as technology preview centers, training first-year teachers and preservice teachers in technology use, and training personnel on the use of TENET, the statewide computer network for teachers, with connections to the Internet.

These examples suggest a number of important lessons for implementation (see box 1-5).

CURRENT FEDERAL SUPPORT FOR TEACHER TRAINING AND TECHNOLOGY

As in the past (see box 1-6), multiple categorical programs for different needs and niches continue to comprise the world of federal teacher training programs.[29] Of the 58 programs OTA has identified that support preparation of teachers to use educational technology of some sort, most are small (under $10 million). **What is striking about most of these programs is the optional nature of support for technology-related training.** Not one program is devoted exclusively to **technology-related** teacher training, although federal agencies sometimes choose, in the case of discretionary grant programs, to make technology-related teacher training an absolute priority for one funding cycle.[30] The programs that provide the most consistent funding for technology-related professional development usually combine technology with science and mathematics training or include technology-related activities for both teachers and students, as in the Star Schools program.

In myriad programs, it is up to state, local, or university grantees to decide whether technology-related training is provided at all and in what form. This is the case with large formula grant programs, such as the Title I Chapter 1 (usually referred to as) program for disadvantaged children and the Vocational Education Basic Grant program, as well as smaller demonstration programs, such as the National Science Foundation (NSF) Teacher Enhancement program. Even programs with a primary focus on teacher development seldom mandate or recommend that grantees consider technology as either a topic for training or a mode for delivery. And with few exceptions, the federal government does not collect data from grantees in the format or detail necessary to discern which projects are actually providing technology-related teacher development, or how much they are spending for it, or what the impact has been.

FEDERAL POLICY ISSUES AND OPTIONS

The appropriate federal role in education has always been debated. The extent to which there should be a federal role in assisting teachers to make the connection with technology is and will continue to be part of this debate.

There seems to be little question of whether technologies should be used in the nation's schools for purposes of instruction, administra-

[29] The General Accounting Office counted 86 programs supported by the federal government in support of teacher training of all kinds. "Multiple Teacher Training Programs" (Washington, DC U S General Accounting Office, February 1995)

[30] An *absolute priority* means that only projects that address the priority will be funded in a given year Priorities change from year to year

BOX 1-5: Some Lessons About Technology Implementation

A number of schools, districts, and states have made the adoption of technology a priority. Important lessons from these sites include:

- **Educational rationale should guide technology decisions.** Developing a technology plan—thinking through the goals for technology use at the local site and involving teachers in the planning process—is key to successful implementation
- **Those wishing to invest in technology should plan to invest substantially in human resources.** Training, maintenance, technical support and time to learn to use the technology have proven to be constant and continuing, yet key expenditures. Recently, several states (e.g., Texas and Florida) have recommended that at least 30 percent of technology funds be spent on training.
- **Teachers cannot use technology without systemic support.** The roles of principals, other administrators, and the community are critical in fostering sustained use of technologies. Other staff, such as media specialists, can provide technical and motivational support for teachers in their building if time is allocated for them to do so
- **When it comes to learning to use technology, "hands-on" training is more than a gimmick or motivator.** It is a necessity Teachers must have the chance to make the computer (or camera or whatever) work, and gain confidence in their own competence, before they try the same thing with their own class
- **Access to equipment is essential.** It is extremely frustrating for teachers to learn to use technology in a workshop, then return to a classroom where the technology is not readily available. Many programs are increasing teacher access to technology by letting them take the equipment home (e g , laptops, summer loaner programs, etc) since most teachers put in many hours at home grading, planning, and preparing. Putting technology in the hands of teachers—allowing them to see and explore how technology can help them do their jobs—can be an effective way of motivating teachers to learn about technology
- **Although there are a number of models for training teachers and implementing technology, there is no one best way of using technology or of training teachers to use technology.** Districts are most successful when they have multiple and complementary training and support strategies
- **Followup support and coaching is as essential to effective staff development as is the initial learning experience.** Teachers don't "learn it all" at a training session—even if it extends over several weeks. When they return to the classroom the unexpected inevitably happens. At this point, teachers need to be able to reach out for technical assistance and support.
- **Many technology-rich sites continue to struggle with how to integrate technology into the curriculum.** Curriculum integration is central if technology is to become a truly effective educational resource, yet true integration is a difficult, time-consuming, and resource-intensive endeavor
- **When conditions are right—resources, time, and support are high—exciting things happen in technology-rich environments.** Today we are faced with the broader issues of how to move these lessons to the second stage of dissemination. How can these lessons be translated when resources aren't as rich? When teachers aren't as enthusiastic or energetic? Issues for policy consideration include the need to consider the development of products based on research and experience of experimental sites, seeding of more "real world" projects, and better dissemination of lessons learned

SOURCE Office of Technology Assessment 1995

tive efficiency, and teacher professional development, *as appropriate*. The policy options in this report focus on the question of teachers' roles in accomplishing this goal, and on the advantages and disadvantages of selected legislative actions related to teachers and technology.

The array of technology for education is diverse, changing, and flexible, and these characteristics enable development of hardware, software, and learning environments that can suit special needs, allow new approaches to teaching and learning, strengthen teaching, and create excitement in the classroom. The broad and expanding range of educational technologies complements the diversity of the American education system. In the past, federal policy has often floundered on the enormous scale and differences that characterize American schools, compounded by the strong tradition of state and local control. In thinking about policy for technology, decisions can be made to allow for variation, change, experimentation and differing outcomes, and so strength can build upon strength.

Federal policy over the past decade has too often focused solely on generating funds for capital investment in hardware. Other policy initiatives have been diffuse and, until recently, there has been little focus on technology by the leadership of the U.S. Department of Education. Insufficient attention has been given to teacher preparation, development and support of learning tools and techniques, issues of connectivity, and the constantly growing demands on teachers' time. While costs of hardware will remain an issue, it is important to remember that technology capacity continues to increase at an astounding rate and that hardware costs often drop relevant to the power one purchases. While direct funding or other financial incentives are, of course, effective ways to demonstrate leadership and commitment, OTA concludes that, if the federal government wants to support the expansion and appropriate use of technologies in K-12 schools and colleges of education, federal policy must go beyond funding. Leadership; a commitment to research, development, and dissemination; an increased focus on teachers; and attention focused on issues related to the challenge of school access to the emerging electronic telecommunications infrastructure are equally critical.

OTA has identified a number of necessary components for taking advantage of learning technology and optimizing use of technology by teachers. These components are summarized in box 1-7 and discussed below.

Federal Leadership: Legitimizing, Funding, and Targeting Technology

If it wants to promote the appropriate uses of technology in elementary and secondary schools and colleges of education, the federal government can **move to fully legitimize the role of technology to enhance instruction, increase teacher productivity, create new teaching and learning communities, and support educational change.** Federal signals that technology is not only welcomed but needed in schools will strongly influence state and local decisions over the next five years. Until very recently, with little focus on the use of technology within the Department of Education, technology was an acceptable expenditure in many programs but was not held up as a tool for improvement. An important exception to this was the Star Schools Program, initiated by Congress in 1988, which has addressed a number of educational needs for students and, to a lesser degree, teachers, through emerging applications of technology.

The Goals 2000: Educate America Act (P.L. 103-277) called for creation of an Office of Educational Technology within the Department of Education. The need for high-level coordination of technology issues had already been recognized by the Secretary of Education in the appointment of a Director of Educational Technology in 1993. An office like this can **provide the much needed spotlight on technology, coordinate programs, and lead in evaluating and disseminating research results.** Continuing to support this office, and seeing that adequate resources and authority are provided, will be critical.

A valuable related step is to **make the most of the national long-range technology plan to be**

. . .

BOX 1-6: Past Federal Efforts To Support Teacher Development

Although it is in the national interest to have a high-quality teaching force, the federal role in teacher preparation and professional development has been limited. There are exceptions: spheres where the federal contribution has been larger and more influential, such as teacher training in mathematics and science, and personnel preparation for special education. In general, however, the federal government has shown caution about becoming too deeply involved in an area traditionally considered a state responsibility, and until very recently has avoided even the suggestion of minimum federal standards for teacher education. It is the states that have exercised primary authority for teacher preparation, licensing, and certification, and more recently, competency testing. Substantial responsibility for preservice education also rested with universities and for inservice education, with local school districts.

In keeping with this limited role, **federal contributions for teacher training have been modest compared with overall federal spending for education.**

Purposes of Federal Involvement In the Past

The federal government became involved in teacher training for a variety of reasons. Often the impetus was a perceived crisis, such as threats to American competitiveness or widespread teacher shortages. In other cases involvement was an outgrowth of other federal commitments. The enactment of federal programs to improve education for the handicapped, for example, created new demands for specially trained teachers to staff these programs. Similarly, effective implementation of federal drug education programs required new training for teachers. Other motives for federal action stem from dissatisfaction with the quality of teacher education or with other aspects of K-12 education.

This diversity of motives resulted in programs that had various purposes, took various forms, and employed various strategies.

Impacts of Past Programs

Past federal programs had many positive effects on teacher preparation and professional development. It might be said that the federal government helped give credence to the concept of inservice education and professional renewal, through such programs as the National Science Foundation teacher institutes and the National Defense Education Act institutes and Teacher Centers.

developed by the Secretary of Education in accordance with Goals 2000. This plan could provide a long-overdue strategy for the federal role in educational technology, not only in ED but across the government. It is crucial that the Secretary take maximum advantage of the directive in the law to join forces with other agencies to produce coherence and vision at the national level. Using all national agencies and programs wisely to expand, evaluate, and build upon knowledge in educational technology is a policy model that can also apply to federal programs affecting teacher preparation and the professional development of the current teacher force.

The executive branch is involving professional associations and citizen groups, as well as federal agencies and researchers, to develop a plan with foresight and credibility. An important caution, however, is that the plan must respect and build upon the extraordinary level of change occurring in technology capacity and the multitude of developing applications. The plan should be a framework for an environment of experimentation and learning, evaluation, and sharing of results. A plan of this nature could call forth rich results, opportunities to learn from problems as well as successes, and build respect for state and local expertise and decisionmaking.

Goals 2000 contains other provisions that could set the direction for educational reform for the next several years and could be used to leverage improved technology policy. A key provision

BOX 1-6 (cont'd.): Past Federal Efforts To Support Teacher Development

Although federal training programs never reached more than a small percentage of the total teaching force, this should not obscure the fact that many millions of teachers benefited from federally supported training. In some subject areas and specialties enough teachers were trained through federal programs to have a significant effect on instructional quality or teacher supply. Mathematics and science is a case in point. Even if the National Science Foundation institutes reached somewhat fewer teachers than the agency's estimate of half the math and science teachers in the nation, there were still enough trained to constitute a potent force for improvement within their discipline

The federal government was also a major force in the growth of certain teaching subspecialties, such as special education, bilingual education, and instructional media. In a sense there was a chicken-and-egg relationship between federal funding and the need for specially trained teachers. On one hand, it was the power of federal mandates that created a demand for some subspecialties in the first place On the other hand, federal intervention filled a void because the special needs of some children were not being met through traditional instruction or teacher preparation.

Federal aid also changed the composition of the teaching force. Scholarships, fellowships, and training opportunities broadened access to the teaching profession for students from blue-collar or low-income families and for minority individuals Federal programs such as Teacher Corps attracted talented and energetic persons into teaching who might have pursued other careers.

Participation in federal training programs produced substantial improvements in the knowledge, attitudes, behavior, and career advancement of many teachers At the school district level, federal funding sometimes provided the external stimulus needed to promote change. Federally supported training familiarized many teachers with instructional approaches that were once considered innovative, such as individualized instruction, interdisciplinary approaches, team teaching, and multicultural education And most significantly for this study, the integration of various technologies into the classroom —including audiovisual materials, educational television, and computer technologies—was hastened and encouraged by federally supported training.

SOURCE Office of Technology Assessment, 1995 based on Nancy Kober, "Teachers and Technology The Federal Role " Office of Technology Assessment contractor report, May 25, 1994

authorizes federal grants to states that develop "a systemic state-wide plan to increase the use of state-of-the-art technologies that enhance elementary and secondary student learning and staff development."[31]

In addition, states that submit an approved application will receive funds under Goals 2000 to establish state content and performance standards for student learning. Whether these standards will instigate the massive reforms desired by advocates will depend on what the standards contain and how seriously they are taken. The *inclusion* **of technology issues in these standards, however, could signal that technology is an appropriate tool for all core subjects, while the** ***omission*** **of technology could prove a genuine setback.** Although the federal government does not have the authority to dictate the substance of these national and state standards, the law established a National Education Standards and Improvement Council (NESIC) to review and "certify" the standards. If NESIC or some variant

[31] Public Law 103-227, 20 USC 5897.

BOX 1-7: Areas for Federal Policy

1 **Federal and state leadership that articulates the value of integrated, technology-based teaching and legitimizes technology as a path to achieve educational goals.** This leadership will be meaningful to the extent that it is supported by commitments to fund and encourage technology use, and is linked to continuing research, development, and dissemination. It can also focus attention on the potential of technology for providing resources to improve the preparation of new teachers and as a valuable tool for the "just-in-time training and support" for professional development.

2 **Increased focus on teachers, both in training and in the field, including: time and money to allow teachers to learn to use technology, support for their professional growth, respect for the complex nature of learning and the many demands facing teachers today, and research on how technology affects teaching and school change.** Congress has taken some steps to promote increased technology use in schools, and greater support for teachers who use technologies. Technology planners in K-12 schools and in colleges of education can take advantage of such support to further their goals

3 **Provisions to ensure that access to data and information, through services such as the Internet, are available to all teachers and students.** The special needs of education are likely to be overlooked or neglected unless they are built into federal, state, local, and private sector decisions on telecommunications regulation and funding over the next few years. Access to high-quality information and necessary resources may be today's measure of equity in education

4 **Commitment to research, development, and dissemination that will advance technology use by and for teachers.** The development of powerful curriculum products, tools, and telecommunication resources is often beyond the capability of individual states, districts, or schools. The private sector may be able to play a greater role in developing new educational technology products than they have in the past, but some observers note that education may not be a promising enough market unless incentives are found to aggregate it.[1] Federal support may be needed to infuse the appropriate funding, expertise, and attention to standardization, evaluation, and dissemination that can facilitate school use of promising technologies and their applications. Furthermore, research is needed on teachers and technology use if these applications are to be used most effectively

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[1] The Software Publishers Association reports that the average elementary school spent $12 500 and the average high school spent $10 400 on software in the 1993-94 school year. Software Publishers Association, *SPA K-12 Education Market Report* (Washington DC July 1994). Overall, the annual expenditures made by K-12 schools has been estimated to be approximately $1 billion, and software purchased by K-12 schools has been growing at the rate of about 20 percent per year. Ronald E. Anderson, "The Technology Infrastructure of U.S. Schools," *Communications of the ACM* vol 36, No 5 May 1993 p 72

SOURCE Office of Technology Assessment 1995

is supported, its criteria for certifying standards could include a review of whether technology needs and methods have been considered.[32]

Another very critical step that the federal government can take to provide both leadership and dollars is to **make the most of the opportunities available to support and encourage technology-related professional development in current programs, and the Improving America's Schools Act (P.L. 103-382), with its amendments to the Elementary and Secondary Education Act of 1965.** The Office of Education-

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[32] Legislation has been introduced that would eliminate funding for NESIC (H.R. 977, H.R. 1045, S. 323, and S. 469, all in the 104th Congress)

al Technology will be well suited to lead a review of existing and proposed programs to ensure that they give fair consideration to technology-related expenditures and to determine whether there are program regulations, guidelines, and accounting procedures that either discourage expenditures for technology and professional development or have untapped potential to encourage them.

P.L. 103-382 also included a major new **Technology for Education Act** that could be the centerpiece of a stronger federal role in providing technology-related teacher development, ensuring greater access and equity in the area of technology, and demonstrating and disseminating several promising educational applications.

The federal government could **take several steps to achieve better use of programs and funding authorized under current laws. Federal regulatory actions could include establishing priorities or bonus points related to technology in competitive grant programs, issuing policy statements highlighting acceptable expenditures for technology and professional development where the law permits, and eliminating unnecessary nonstatutory restrictions on the use of funds for technology or training purposes.** A message from federal leaders can send a strong signal of reassurance to state and local educators that they can acquire and upgrade technology and, most important, train teachers in its use with no regulatory constraints.

Particular attention should be focused on the revised **Eisenhower Professional Development Program**, given greater emphasis in P.L. 103-382, which calls for a larger federal teacher professional development effort in several critical subjects. The Secretary of Education could encourage states, universities, and school districts to consider integrating technology into the various professional development activities supported under this program.

Other federal programs that should be examined include the programs for students with special needs that are a cornerstone of the federal role in education, particularly **Title I of ESEA for disadvantaged children (referred to commonly as Chapter I), the Part B state grant program under the Individuals with Disabilities Education Act (IDEA) (20 U.S.C. 1400 et. seq.), and the Bilingual Education Act (20 U.S.C. 7401 et. seq.).** Together these programs channel almost $10 billion to states and school districts. Educational technology has become an important tool for delivering instruction to the children served by these and other special needs programs, yet teacher professional development has not kept pace.

In Chapter 1, for example, technology continues to be used primarily for drill and practice of basic skills rather than for the more promising and integrated kinds of teaching described in this report. Amendments to Chapter 1 in P.L. 103-382, and discussions about future policy directions in IDEA, are stressing improved program quality and professional development in these programs. For example, as justification for changes in Chapter 1, P.L. 103-382 states that, "Since 1988. . .[the nation has learned that] insufficient attention and resources are directed toward the effective use of technology in schools and the role technology can play in professional development and improved teaching and learning."[33]

Similarly, the 1994 Bilingual Education Act authorized $215 million in grants for activities intended to educate limited-English-proficient children and youth so that they would be able to "meet

[33] Public Law 103-382, Title I, 108 Stat. 3520, sec. 1001 (c)(6).

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TABLE 1-4: Major Federal Policy Levers for Enhancing Teachers' Use of Technology and Teachers' Professional Development

Legislation or Program Level	Program	Goal	Funding[a]
Improving America's Schools Act (P.L. 103-382) (amending and revising the Elementary and Secondary Education Act (ESEA) of 1965 and several other federal education statutes)	ESEA Title I Helping Disadvantaged Children Meet High Standards	Major activities supported grants to states for funding local improvement programs, family literacy, education of migratory children, others	$7.2 billion
	ESEA Title II Dwight D. Eisenhower Professional Development Program	Supports professional development in core academic subjects	$359 million
	ESEA Title III Technology for Education Act	Expanding access to and use of educational technologies, strengthening the technology infrastructure, supporting technical assistance and professional development	$40 million
	■ Star Schools	Improve instruction through grants to telecommunications partnerships for programming and facilities	$30 million
	■ Challenge Grants	Innovative projects, can include teacher training	$27 million
	■ National Activities	Regional technical assistance and teacher training consortia and other implementation activities	$13 million
	■ Product Development	Develop, produce and distribute technology enhanced instructional resources and programming for instruction or professional development	unfunded

	ESEA Title VI Innovative Education Program Strategies	In the past, districts have spent funds on hardware and software purchases and professional development	$347 million
	ESEA Title VII Bilingual Education, Language Enhancement, and Language Acquisition	To educate limited-English-proficient children and youth to meet the same rigorous standards for academic performance expected of all children and youth	$350 million
	ESEA Title XII: Education Infrastructure Act of 1994	Ensure the health and safety of students through repair, renovation and construction of schools	$100 million
Individuals with Disabilities Education Act (20 U S C 1400) • Eligible for reauthorization in 104th Congress		Educating children with disabilities	$3 3 billion
Goals 2000 Educate America Act (P L 103-227)	Part C Leadership in Educational Technology, Office of Educational Technology	Encourage technology as a resource for providing instruction and professional development, and teacher training as part of technology investments	NA
	Part B National Education Standards and Improvement Council, Assessment, Development and Evaluation Grants	Grants to states for plans, part of broader state improvement plans, to increase use of educational technologies for learning and staff development	$5 million (fiscal year 1994)
Revisions to Communications Act of 1934	Revisions will be important to pricing of telecommunications services	To be determined	NA

(continued)

TABLE 1-4 (cont'd.): Major Federal Policy Levers for Enhancing Teachers' Use of Technology and Teachers' Professional Development

Legislation or Program Level	Program	Goal	Funding[a]
Other Selected Areas and Activities			
Department of Commerce	Advanced Technologies Program - education activities		
	Public Telecommunications Facilities Program	Develop telecommunications facilities to serve local communities (distance learning projects have been supported in the past)	$29 million
	Telecommunications and Information Infrastructure Assistance Program	Planning activities and demonstration projects for telecommunications networks	$64 million
National Science Foundation	Teacher Enhancement Program	Funds teacher training programs in math, science and technology	$101 million
	Teacher Preparation	Supports projects to improve undergraduate teacher preparation in math and science and technology	$18 million
	National Education Infrastructure for Networking	Demonstrates innovative applications of networking for education	$15 million
	Applications of Advanced Technologies	Funds research and demonstration in revolutionary technologies for education	$10 million
Public Broadcasting Act of 1967 (PL 90-129)	Corporation for Public Broadcasting	Support for development and activities in support of education and professional development	$285 million (estimated)

[a] FY 1995 appropriation unless otherwise indicated

SOURCE Office of Technology Assessment 1995

the same rigorous standards for academic performance expected of all children and youth."[34] Federal grants were authorized for projects using educational technologies, "if appropriate," among a range of other permitted activities. Furthermore a subpart of the Bilingual Education Act was devoted to professional development and, among the evaluation components required of recipients of bilingual education capacity and demonstration grants was a demonstration of "appropriateness of the program's staff professional development."

The recognition of technology and professional development in these legislative authorizations represents an opportunity to encourage states and school districts to use a portion of their program funds for additional professional development in forming the effective uses of technology for special needs children. However, without specific requirements in legislative language, it will be up to grant applicants or the Department of Education (in regulations or grantee requirements) to ensure that professional development and/or technology are foci.

Other programs, such as Star Schools, have as their primary purpose the use of technology to meet educational needs. These programs can continue to be leaders in experimentation, helping to add to the store of knowledge on how technology is effectively used.

OTA also finds that while great interest centers on advanced educational technology such as integrated curricula products and multimedia tools, **"small" technology is also needed to bring schools along the learning curve.** Telephones, voice mail, fax machines, calculators, television sets and VCRs, camcorders and editing tools all have a place in today's classrooms, but are often denied to teachers. In fact, providing a classroom telephone that puts a teacher in direct contact with a parent can facilitate the parent-teacher communication and parent involvement that many believe is essential to improving student achievement. Yet tools as basic as telephones are denied for a complex set of reasons, and cost is normally one of the smaller issues. Traditional methods of conducting school business, reluctance by principals to allow teachers more control over their professional lives, and general fear that teachers will somehow "misuse" telephones are frequently cited to researchers as reasons that telephones and other technology should not enter classrooms. **Congress may not be able to change such attitudes, but it or the executive branch could set the tone by taking steps to encourage the installation of telephones in classrooms.** As discussed earlier in this chapter, costs are likely to be a factor inhibiting the installation of technologies, whether small or large.

Research, Development, and Dissemination

Support for educational research, development, and the dissemination of research results has traditionally been viewed as an area of national concern, supported by federal funds. This is also true of such activities as they are related to educational technologies.

First, more and better information is needed on the effectiveness of various technology tools, and applications, including whether and how technologies work for teachers. Are some types of training or support more effective than others? Are they more effective for some type of teachers (by field) or by level (elementary versus secondary)? Some literature suggests that educational technology "takes off" when there is a critical mass of teachers committed to using it. Can this be substantiated? Experience has shown that teachers must be given time to learn and prepare, adequate technical and content support, and a supportive attitude from the principal's office, but surely there is more to be learned about teachers and effectiveness. Although some recent studies are beginning to investigate how the teacher's work life is changed by technologies, there has been little research on teachers as members of work groups, or

[34] Title VII of the Amendments to Title I of Public Law 103-382.

Research to date has looked at student achievement, comparing results of instruction with technology versus other methods. However, there are other important factors that make simple comparisons misleading.

on the breadth of activities teachers undertake. All these are fertile areas for federal research.

Alternatively, the federal government, states, school districts, and schools could leave the topic of effectiveness research to private sector product developers or form research partnerships with local university-based, research-oriented colleges of education. One disadvantage of a private sector approach is that product developers may use research as an opportunity for marketing. Publicly funded research may be more likely to point out both the positives and negatives of a new technology. Clearly, the education community needs additional exploration of research strategies that will lead to providing both accurate and timely results for use by adopters of new educational technologies.

Development of advanced integrated curriculum materials, projects and tools could be appropriate investments for the federal government, continuing a long tradition of research and quality applications. Because the upfront investments are high, and state and local funds for development are limited, federal support has been important in the past. Many of the innovative technology applications reported on in this study have been supported by federal research funds, particularly the National Science Foundation.[35]

The work of the Department of Education, the Department of Energy, the National Technical Information Administration, the Department of Defense and its research agencies, and others has also been invaluable in creating new methods, new technologies, new materials, and new approaches with educational technology. Projects of this type can also enhance the link between teachers and the research community. Comparatively small amounts of money in the federal budget have had substantial impacts on technology use in schools.

Much of the focus and experimentation to date has been in the areas of math and science; work is needed in other subject areas. If Congress wishes to encourage the development of powerful, flexible learning tools and applications, federal support for continuing research and development will be necessary. **The development of the next generation of integrated curriculum projects can work hand-in-hand with proposed educational standards in all curricular areas, and could be undertaken as a national research priority.**

Congressional concern about timely development of new educational technology software was reflected in the 1994 Technology for Education Act's provisions on product development. Grant applications were encouraged that "promote the acquisition of higher-order thinking skills. . ., convert technology resources developed with support from the Department of Defense and other

[35] For example, the National Science Foundation's Applications of Advanced Technology program.

federal agencies for effective use in the classroom; . . .[and] show promise of reducing the costs of providing high-quality instruction." No funds were appropriated for this program in FY 1995.

The federal government's seed money for product development can be said to have resulted in a sequential form of public-private partnership. A good example is the Kid Net project initially funded by NSF, further developed by TERC (a not-for-profit organization), and eventually turned into a marketable product that schools can purchase from National Geographic, which sells Kid Net as part of their profit-making company.

Alternatively, Congress could leave development of new education technologies entirely to the private sector. It is unclear, however, that K-12 schools, with their persistent constraints on resources, represent enough of a market for educational technology product developers. For example, the Software Publishers Association (SPA) estimates that K-12 schools spent an average of about $11,000 each on software in the 1993-94 school year.[36] In half the school districts surveyed by SPA, funds for software purchases came primarily from discretionary funds held by principals and teachers, from donations or business partnerships, or from school fundraising efforts. Possible tradeoffs between public and private sector approaches to new product development would be a good subject for further analysis.

Federal action can improve dissemination of research results. Experimentation with new technologies is only the beginning; teachers need to know what works and why. Dissemination of research results has not been adequately emphasized in the past, but it too can be enhanced and extended through technological means.

Educating New Teachers, Professional Development and Teacher Support

People preparing for teaching and teachers in the field face a vast and constantly growing set of demands for their time and attention. Mastering technology use may be only one goal placed before them. Yet using technology with facility is a daunting challenge for most people; teachers are no exception. One of the clearest findings of the OTA case studies and other research is that even very highly motivated teachers require substantial amounts of time—often over a three to five year period—before they feel fully versatile with a complicated new technology and are able to expand technology tools to fit their particular teaching goals. And finding time in the teaching day and year for training, collaboration, and "messing around with" technology is a bane of the profession.

A goal for states and localities that want their schools to function more effectively is to find ways to give teachers time for lesson preparation and learning, and support for continuing work. Exposure to new materials and resources, training in use of actual technologies, and development of new classroom patterns take time. They also require strong organizational support from principals, administrators, and colleagues. There is little point in acquiring hardware but making no provision for teacher development and support. Fortunately, technology itself offers some inherent solutions, if teachers can have equipment to use when they have time, and can be rewarded for learning. The use of telecommunications linkages to provide resources and opportunities for training is one of the most promising aspects of technology, but it cannot be a substitute for adequate time. As mentioned earlier, states with a strong commitment to effective technology use are beginning to allot as much as 30 percent of technology expenditures for teacher training and support. This includes the cost of substitute teachers as well as training resources.

The demographics of the teacher pool and the school population indicate a substantial increase in the number of teachers required just after the turn of the century. Teacher preparation has al-

[36] Software Publishers Association, *SPA K-12 Education Market Report* (Washington, DC: Author, July 1994).

ways been the province of states, colleges and universities. The federal government has played a limited role in the general area of teacher professional development, despite the fact that a large number of federal programs have been aimed at this issue and some have made an impact in specific subjects such as math and science (see box 1-6).

Prior federal efforts to improve teaching or increase the teacher pool reflect a scattershot approach. Preservice programs have included fellowships, scholarships, loans, support for certification efforts, and some direct training programs aimed at specific kinds of teachers or curricular materials. Current teachers have been exposed to summer and academic-year institutes, seminars, workshops, and one-time training sessions. Federal funds have provided institutional support to local school districts and schools of education to build their capacity. Strategies to magnify the effect of federal dollars have included targeting key teachers who are expected to train their peers or promote school change, training teams of teachers and administrators from one school, developing model training programs and, to a more limited degree, encouraging collaboration between school districts and universities.

A review of many other federal programs (see chapter 6) makes clear that in some instances, technology has been introduced to schools, but funding has been limited to the cost of hardware or software only, with no allocation for the preparation and support of teachers and other personnel. This strategy is a bad investment.

Congress could more definitively express its wishes to see adequate budgets for teacher support and training in future legislation or report language.

OTA concludes that an effective policy mechanism would be to **require that all applications for federal financial help that include technology show adequate budgets for high-quality support and preparation of staff.** This approach would remind anyone preparing an application how important planning is to assure technology will be well used: it will help to assure that teachers will be given support over the long term, not just when the technology is brought in the door.

States that are leading technology users have already adopted this approach. The Texas Education Agency recently recommended that districts allocate 30 percent of their technology funds for hardware, 30 percent for software, 30 percent to staff development, and 10 percent to maintenance. For the 1993-94 school year, the Florida legislature allocated $55 million for technology and $8.65 million for software, and required that schools seeking these funds set aside at least 30 percent for teacher training.

The importance of teachers for the effective use of technology, the need for expanding the population of teachers in the next decade, and the inclusion of teacher professional development in the national education goals suggest that **the time is ripe to consider whether the nation wishes to make a more direct and coordinated commitment of federal attention and resources for teacher preparation and professional growth.** Goal 4 of the National Education Goals specifies that by the year 2000, "the Nation's teaching force will have access to programs for the continued improvement of their professional skills and the opportunity to acquire the knowledge and skills needed to instruct and prepare all American students for the next century." Meeting this goal must surely mean competence in working with technology. **Policy decisions to meet this challenge could be carried out through the revised Eisenhower program, through other innovation programs such as the Fund for the Improvement of Post-Secondary Education, through broad initiatives such as the National Teacher Corps, or even through a national-level teacher certification.** A first step toward making this policy decision would be a review and evaluation of existing programs as recommended above, and consultation with professional societies, educators, parents, and others to identify appropriate federal actions.

Colleges of education remain generally low on the totem pole when value is assigned to undergraduate and graduate training. One force working to improve teacher preparation is a movement to raise standards for accreditation of teacher colleges; state and federal policy decisions that em-

phasize accreditation (or other outcome measures) are likely to encourage improvement. Awards and honors bestowed by professional education groups also contribute to higher status. **The federal government can play a role through its grantmaking activities, by encouraging and supporting technology applications when considering funding requests from schools and colleges of education.** In particular, education research centers and major graduate educational sites could be strongly encouraged to adopt teaching with technology, so that new teachers learn by example. In teaching, as in most other professions, the techniques modeled for new entrants by their own teachers are extremely powerful. If new teachers have not experienced the power of learning through technology-based tools, they will have less motivation to make the effort to master these tools themselves.

In addition to relying on the public sector for support, states, school districts, and schools that accept offers of hardware or installation from private sector companies (e.g., computers, wiring schools or providing other hookups to electronic information sources) could request or require that the companies also provide meaningful levels of initial training and continuing support for teachers. Some companies have provided such support on a short term basis (see chapter 4). Companies might be persuaded to agree with requests for more intensive support for technology-using teachers because technology-friendly teachers are likely to make more and better use of the technologies provided, and expand companies' markets. Schools may be reluctant to make such demands in the belief that the companies will be less likely to offer any assistance in the future, but the strategy might be worth trying and monitoring, as a means of providing more effective private sector support to schools.

While it is clear that diffuse, shifting federal teacher training programs that reach only a tiny fraction of teachers cannot change the profession, it is also clear that if a decision were made to intensify the emphasis on use of technology as a resource for preservice and inservice teacher development, efficiencies and improvements could be made in the overall ways these activities are conducted.

Access to the Emerging Information Infrastructure

In the early days of "computer education," great attention was given to the distribution of machines per capita. It is becoming clear that actual equity for technology today goes well beyond machine counts; in fact, machines are a necessary but not sufficient component of teaching and learning. Students in some classes may have access to machines, but nothing available from or through the hardware of any real value. Likewise, teachers need to be able to locate and retrieve information, collaborate with others electronically, and develop and share materials at their own pace and for their own needs. In the information age, access to necessary information may be the true measure of equity. Over the next decade, many individual, local, state, federal and business decisions will determine whether this resource is broadly available or greatly restricted.

At the present time, computer networks, electronic communities, software for searches and retrieval, and myriad other elements of an emerging information infrastructure are coming into use on a highly idiosyncratic basis. This takes advantage of technology capacity and caters to individual needs. It means, however, that teachers, schools, and students can easily miss the boat.

An intense debate is now under way about the role of education with respect to the emerging national and global information infrastructure. The policies that result from this debate may be the most difficult and important decisions of all. All sectors of the economy are struggling to come to grips with the new opportunities, products, and choices offered through these developing technologies and policies. The constantly shifting definition of the system, changing technologies, entry of new public and private participants, and the simple newness of the system mean that it is very hard to articulate policy choices for the near future, much less for a decade. Some conclusions seem clear, however:

- Having ready electronic access to information is likely to be necessary for schools.

  The costs of these services cannot be fully determined but will include hardware, software, connectivity, use of guides and helpers to effectively navigate the system, and fees for line access and use. How the nation's schools might afford ready electronic access to information, especially in a time of restricted or even reduced funding for education, is a major policy concern. School districts are facing huge costs just to bring their aging, dilapidated school buildings to where they meet basic standards. The General Accounting Office reports that $112 billion is required for the repairs, renovations, and modernization required to restore the nation's 80,000 public schools to good condition and to comply with federal mandates related to accessibility and safety regulations, for major building features such as plumbing and environmental conditions such as ventilation, heating, lighting, or physical security.[37]
- Intellectual property and privacy issues are important for schools, as they are for other groups.
- The K-12 education community, and the college-of-education communities are not well positioned to negotiate effectively in the open market or in the regulatory arena for rights and access, and are unlikely to have the funding, legal support, and bargaining power to protect themselves, unless there is intervention or guidance from state and national policymakers or the private sector.

Congress is considering a number of approaches for education and the emerging telecommunications complex. Some reflect the desire to apply the concept of "universal service," contained in the current legal framework for the broadcasting system, to schools. There have been suggestions to set aside portions of the information infrastructure for school and other public uses, and suggestions to provide special sources of funding for school connections to these system.[38] The education market could possibly be aggregated into a purchaser that generates substantial market clout. This model reflects the success of some states in centralizing purchasing of hardware, specifying arrangement for network connections, and specifying software from competitive vendors. For example, some states have regulated tariffs and established targeted subsidies for schools. Georgia, for example, through its state department of telecommunications, procures telecommunications services for schools at the same prearranged rate that state agencies pay.[39]

In California, the Industry Council for Technology and Learning worked with the Public Utility Commission (PUC) in developing a PUC Educational Telecommunications Plan for the state. When the commissioner, who originally did not know that the schools were not connected, met with the state's education agency, together they developed recommendations that overcharges to customers be channeled to education. This amounted to an estimated $40 million for telecommunications in the schools per year. As a part of this partnership, Pacific Bell pledged to connect every school in the state.[40] Currently, 18

[37] U.S. Congress, General Accounting Office, *School Facilities: Condition of America's Schools* (Washington DC: February 1995)

[38] See, e.g., National Association of Secondary School Principals, Council of Chief State School Officers, National School Boards Association, American Library Association, and National Education Association, press release, Nov. 15, 1994.

[39] James Bailey Matthews, vice chancellor, Information Technology for the University System of Georgia, Atlanta, GA, personal communication, Mar. 13, 1995.

[40] John Cradler, Far West Education Lab, presentation to National Coordinating Council-Technology in Education and Training, meeting, Washington, DC, December 1994

BOX 1-8: Organization of the Report

This first chapter highlights some of the main findings of the study and lays out several policy options for Congress. It also analyzes several issues related to educational access to the global information infrastructure, including rough estimates of cost of and possible financing strategies for developing a telecommunications infrastructure with various levels of school access. It addresses other issues relevant to emerging electronic information sources and teachers, such as intellectual property rights, confidentiality and privacy of records, and limits on student access to potentially obscene or harmful materials.

Each of the next five chapters begins with a summary of key findings from that chapter.

Chapter 2 discusses the potential of technology to support, enhance, and, in some cases, redefine the job of teacher. Based on the actual experiences of teachers as reported in interviews, site visits, case studies, and published research, the chapter examines why some teachers are using technology and how it is changing their classrooms and teaching methods. The chapter also describes how technology can help teachers carry out many of the administrative, productivity, and communications tasks associated with their jobs. Finally, the chapter considers how technology can be a resource for teachers' professional growth, whether through formal professional development courses or informal exchanges with colleagues and outside experts.

Chapter 3 provides a statistical picture of the presence and use of technology in schools today. The chapter examines the extent to which schools and teachers have access to various kinds of technologies, including computers, video resources, telephones, and networking technologies. It also looks at how schools actually use these technologies how often, in which kinds of classes, and for which kinds of activities. Finally, the chapter examines state policies for technology access and use.

Chapter 4 analyzes the factors that influence how effectively teachers implement technology. The chapter examines multiple barriers limiting teachers use of technology and describes the resources currently available to support teacher use of technology. Building on case studies of promising practices, the chapter outlines some approaches that schools and districts are currently using to help teachers learn more about technology and draws some lessons about technology implementation from these pioneer sites.

Chapter 5 addresses the role of technology in the preparation of new teachers. It examines the treatment of technology issues in teacher certification requirements and teacher education reform proposals. The chapter analyzes the kinds of technology preparation currently provided to teacher candidates. Drawing on case studies of institutions that have made technology a priority, the chapter also describes some promising approaches for integrating technology into teacher preparation and highlights ways in which technology can improve the teacher preparation experience.

Chapter 6 summarizes the federal role in technology-related teacher preparation and professional development. It outlines current sources of federal support for these activities, the nature and extent of federal commitment, and new opportunities for federal leadership created by recent legislation. The chapter also examines past federal efforts to improve teacher training and promote technology, analyzing their impact and their lessons for future federal action.

states are using preferential telecommunications rates as sources for expanding the use of technology.[41] Legislation proposed (and in effect) at the state level speaks only to telecommunications access rates for intrastate service; any special rates for interstate service would fall within the authority of the Communications Act of 1934.

Congress may be left in a quandary as it considers how much it should do with respect to expanding the technological capabilities of elementary

[41] Ibid

Our children face a future in which technology will touch every aspect of their lives. Teachers want them to be ready.

and secondary schools and colleges of education. Clearly, federal support for an *extensive* expansion of educational technologies, even if it were ideologically desirable, could be costly.[42] Because technologies are advancing so rapidly, there may never be an adequate, up-to-the-minute answer to the question of whether such investments are worth their cost.[43] Some states and local school districts may be able to take on the burden of investing in new educational technologies, even without a definitive answer as to the long-term payoff, but others will not have the resources. Given the federal budget deficit, and the tax burdens felt by American citizens in all localities, an extensive federal investment at this time may not be possible. The analysis in this report suggests strongly, however, that whatever investments in hardware and software are made, and at whatever level, with whatever sources of funds, the investments be made thoughtfully. In this case thoughtful investment will require that infusions of resources be accompanied by concomitant investments in the teachers who will be working with the students and the technologies.

The Department of Education is struggling to keep attention focused on educational access, as it works to define what products the education market needs and how schools can best participate in the emerging telecommunications system. Given the large federal role in interstate telecommunications issues, if schools are not to be left behind, Congress will need to pay close attention to this issue as it debates regulatory and subsidy measures.

Regardless of decisions made about funding, if unintended consequences of new technologies are not to hinder teachers' access to technology and telecommunications, policymakers must be vigilant regarding three additional areas pertinent to education and new information systems. These areas, discussed earlier in this chapter, are privacy, particularly with respect to the records of students, copyright law, and the tradeoffs between protecting children from inappropriate materials and untoward censorship of emerging networks. Protection of intellectual property products also requires effective education of the public about intellectual property rights. This education could begin in school as students, teachers and administrators are connected to online information systems.

CONCLUSION

Bringing about change in the diversified U.S. school system is a formidable task. With over 2.8 million teachers in the United States, and 3.3 mil-

[42] As discussed earlier, the costs of connecting schools, teachers, and students to emerging information technologies and sources are highly uncertain. Available rough estimates suggest the costs on a national basis could be minimal (for minimal interconnectivity) or they could be astronomical, relative to current spending by elementary and secondary schools. In the 1992-93 school year, the National Center for Education Statistics estimates that public and private elementary and secondary schools spent $280 billion (U.S. Department of Education, Office of Educational Research and Improvement, National Center for Education Statistics, *Digest of Education Statistics, 1993*, table 33, October 1993).

[43] True costs will likely vary on both a national and local basis depending on what technology plans are developed, the state of current school infrastructures, technology costs at the time of implementation, and other factors.

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lion estimated to be needed by 2003, any attempt to "retool" or provide the entire existing teacher workforce with new skills or knowledge will need to be done on a very large scale. Most teachers have many years of teaching experience (the median is 15 years) and, at a median age of 42, most attended school before computers were used in the classroom.

Teachers are an incredibly diverse group. Some already have experience with technology—computers at home, for example—while others have never even been shown how to "boot one up." And some teachers are eager to experiment with new ideas even at the risk of failure, while others have little interest, energy, or time for experimentation. The great majority of teachers probably lie somewhere in between.

Technology has been viewed by a few as a frill, by some as a distraction, and by others as an intriguing but peripheral component of education. OTA finds, however, that technologies offer the ability to do many traditional things efficiently and quickly, and a way to encourage entirely new educational opportunities that may be of vital importance to the next generation of learners. If these learners are to make the most of the investments made in educational technologies, support must be given to the teachers who guide and encourage its use.

How can policymakers help to realize a vision of schools where teachers effectively and carefully identify, enlist, and use electronic and communications technology to improve learning?

OTA concludes that if the federal government wants to maintain or enlarge its involvement in this area, the linchpin of federal policy could be a set of initiatives that develop and support technology, and help teachers in their teaching and professional activities. When technology is effectively harnessed to goals identified by teachers, schools, states, and national policymakers, it becomes a vehicle for learning that is powerfully attractive.

One of the principal policy challenges for the next decade is to lead by example and by commitment. The experience of effective technology use in classrooms needs to be widely shared, evaluated and used as building blocks. Resources are needed to develop advanced learning products (hardware, software, curriculum materials, and tools focused on educational applications); both resources and farsighted regulation will be needed to make electronic communities affordable and well designed for schools. Effective policy and well-organized private sector involvement could create technology options that assure resources are equally available across the country, for all teachers, for all students, in all schools.

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